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NORTH AMERICAN CRINOIDEA

WACHSMUTH AND SPRINGER

VOLUME II.

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Memoirs of the Museum of Comparative Zoölogy

AT HARVARD COLLEGE.

VOL. XXI.

THE NORTH AMERICAN
CRINOIDEA CAMERATA.

BY CHARLES WACHSMUTH AND FRANK SPRINGER.

IN TWO VOLUMES WITH EIGHTY-THREE PLATES.

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CAMBRIDGE, U. S. A.:

Printed for the Museum.

MAY, 1897.

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CONTENTS.

THE NORTH AMERICAN CRINOIDEA CAMERATA. By CHARLES WACHSMUTH and
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TABLE OF CONTENTS.

SYSTEMATIC PART (*continued*).

	PAGE		PAGE
BATOCRINIDAE	361-549	Physetocrinus	593
Analysis of the Genera	361	Cactocrinus	600
Geological and Geographical Distri-		Teleocrinus	626
bution	363	Strotocrinus	637
Batocrinites	366	PLATYCRINIDAE	642-740
Batocrinus	366	Analysis of the Genera	642
Eretmocrinus	385	Geological and Geographical Distri-	
Alloprosallocrinus	406	bution	643
Eutrochoerinus	408	Platycrinus	647
Dizygocrinus	413	Eucladoerinus	719
Lobocrinus	434	Marsupioerinus	730
Macroerinus	446	Cordylorinus	735
Doryerinus	454	Coccoerinus	738
Aorocrinus	470	HEXACRINIDAE	741-802
Barrandeocrinus	484	Analysis of the Genera	741
Agaricocrinus	486	Geological and Geographical Distri-	
Acacocrinus	515	bution	742
Compsocrinus	516	Hexacrinus	744
Periechocrinites	519	Arthracantha	747
Periechocrinus	519	Dichocrinus	753
Megistocrinus	532	Camptocrinus	779
Gennæocrinus	547	Talarocrinus	781
ACTINOCRINIDAE	550-641	Pterotocrinus	791
Analysis of the Genera	550	ACROCRINIDAE	803-810
Geological and Geographical Distri-		Geological and Geographical Distri-	
bution	551	bution	803
Actinocrinus	552	Acrocrinus	805
Steganocrinus	578	INDEX	813
Amphoracrinus	586		

BATOCRINIDÆ W. and SP.

MONOCYCLIC. THE LOWER BRACHIALS WITH WELL DEFINED INTERBRACHIALS BETWEEN THEM FORMING AN IMPORTANT PART OF THE DORSAL CUP. RADIALS IN CONTACT EXCEPT AT THE POSTERIOR SIDE, WHERE THEY ARE SEPARATED BY A HEPTAGONAL ANAL PLATE, WHICH IS FOLLOWED BY A SECOND ANAL BETWEEN TWO INTERBRACHIALS.

Analysis of the Genera.

I.

VENTRAL DISK HIGHLY DIFFERENTIATED: THE PLATES LARGE AND HEAVY, FORMING A RIGID INTEGUMENT. ARMS NOT BRANCHING BEYOND THE CALYX

BATOCRINITES.

A. ARMS BISERIAL; BASALS THREE.

1. ANUS AT THE END OF A TUBE.

a. Interbrachials separated from interambulacra by an arch of brachials.

Calyx biturbinate.

Arms short, equidistant; anal tube very long and central; respiratory pores twenty, well defined

Batocrinus.

Arms long, paddle-shaped; anal tube eccentric; respiratory pores twenty

Eretmocrinus

Calyx conical, dorsal cup almost flat, ventral disk greatly predominating in height; anal tube central; respiratory pores twenty

Alloprosallocrinus.

b. Interbrachials connected with interambulacra.

Arms arranged in groups, the openings directed upward; anal tube large, central.

Calyx pyriform to wheel-shaped; arms twenty; respiratory pores not visible . .

Lobocrinus.

Calyx elongate, biturbinate or subovoid; arms twelve to sixteen; respiratory pores ten

Macrocrinus.

c. Interbrachials in contact with interambulacra at anal side only.

Calyx wheel-shaped; anal tube very large, central; arms short, single or paired; respiratory pores twenty

Eutrochocrinus.

- Calyx rotundate; anal tube moderately small, about central; arm openings twelve to twenty; arms long, single or paired, often in the same species; respiratory pores not visible *Dizygocrinus*.
2. ANUS WITHOUT A TUBE.
- a. *Calyx lobed; arms arranged in groups.*
 Calyx more or less elongate.
 Arms heavy, one from each opening.
 Arms ten, recumbent on the dorsal cup; pinules infolding *Barrandeocrinus*.
 Arms one only from each opening, erect, rather heavy *Aorocrinus*.
 Arms slender, paired; upper arm joints spiniferous; posterior oral and proximal radial dome plates extended into spines *Dorycrinus*.
- b. *Calyx hemispheric or pyramidal.*
 Dorsal cup from very slightly convex to concave; arms heavy. Orals and radial dome plates prominent *Agaricocrinus*.
- B. ARMS UNISERIAL.
1. BASALS THREE. INTERBRACHIALS NOT NUMEROUS. COLUMN ROUND.
- a. Arms delicate, joints cuneate, alternately arranged, only interlocking at the tips *Acacocrinus*.
- b. *Arms heavy, joints quadrangular.*
 Arms ten *Habrocrinus*.
 Arms more than ten (?) *Desmidocrinus*.
2. BASALS FOUR; COLUMN QUADRANGULAR.
 Arms slender, joints cuneate; plates delicate and highly ornamented. Interbrachials and interdistichals very numerous *Compsocrinus*.

II.

VENTRAL DISK COMPOSED OF SMALL, IRREGULARLY ARRANGED PLATES, WITH OR WITHOUT ORALS. ARMS GENERALLY BRANCHING BEYOND THE CALYX PERIECHOCRINITES.

A. ARMS BISERIAL FROM THE CALYX UP.

1. *Basals three; anal area wide.*

- Calyx elongate, urn-shaped; plates thin and elongate; arms grouped. Orals indistinguishable. The column with large central canal *Periechocrinus*.
- Calyx depressed globose, plates short and heavy. Arms branching, given off in pairs, their facets contiguous; orals generally represented; central canal large *Megistocrinus*.
- Calyx low, strongly lobed at the arm regions, plates thin, highly ornamented. Arms arranged in clusters. Central canal of moderate size *Gennæocrinus*.

2. Basals four.

Dorsal cup similar to that of *Megistocrinus* ;
arms heavy, flattened on the back. . .

*Abacocrinus**Geological and Geographical Distribution.*

Number of known species.

(Open figures indicate American ; those marked (), European.)

General.	FORMATION.		BATOCRINIDÆ.																			
			Batocrinites.															Periecho- crinites.				
	American.	Approximate European Equivalents.	Batocrinus.	Eretmocrinus.	Alloprosalloocrinus.	Lobocrinus.	Macrocrinus.	Eutrochoocrinus.	Dizygocrinus.	Barandeocrinus.	Aorocrinus.	Dorycrinus.	Agaricoocrinus.	Acacocrinus.	Habrocrinus.	? Desmidocrinus.	Compocrinus.	Periechoocrinus.	Megistocrinus.	Gennaeocrinus.	Abacocrinus.	
Subcarboniferous.	Warsaw.	Mountain Limestone.	2				1		5													
	Keokuk.		3	4	1	4	1	1	14		1	2	10									
	Up. Burlington.		3	9		4	3	3	3		2	5	8						1	1 (1)		
	Low. Burlington.		9	6		2	1				3	3	4						1	1		
	Kinderhook. Waverly. Chouteau.		2								4								1	1		
Devonian.	Hamilton.	Eifel.								1									9	2		
	Up. Helderberg.										(3)											
Silurian.	Niagara.	Wenlock. Gotland.							(1)				2	(19)	(4)			8 (16)			(6)	
	Hudson River.															2						
Total species 203 { 153 (50)			19	19	1	10	6	4	22 (1)	11 (3)	10	22	2		(19)	(4)	2	11 (16)	12 (1)	2	(6)	

Remarks. — The Batocrinidæ and Actinocrinidæ differ from the two preceding monocyclic families, Melocrinidæ and Calyptocrinidæ, in having a large anal plate separating the two posterior radials and resting upon the basals ; and as a consequence of this a hexagonal base, which is composed

in all but two of the known genera in both families of three equal plates. The orientation of these plates is uniform throughout both families, viz.: the interbasal sutures are directed toward the anal plate and the two antero-lateral radials. The anal plate in the Batocrinidæ is heptagonal,

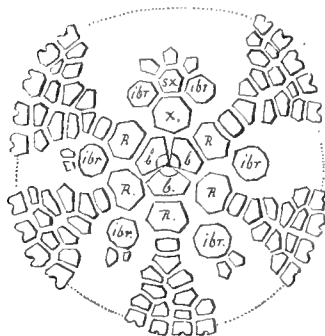


FIG. 18. *Batocrinus*.

b = basals. *R* = radials. *x* = special anal plate. *ix* = supplementary anal. *ibr* = interbrachials.

and is followed by three plates in the first interbrachial row, viz.: a second anal and two interbrachials; whereas in the Actinocrinidæ the anal plate is hexagonal, and is followed only by the two interbrachials, — there being no second anal. We regard the presence of a second anal within the first row of interbrachials as of considerable morphological importance. It is represented without exception from the Lower Silurian to the close of the Devonian in all monocyclic Camerata in which anal plates occur; in the Kinderhook, for the first time, we find both forms together: the Actinocrinoid with but two plates above

the first anal, and the Batocrinoid with three.

When there are three basals, the superior edge of the basal cup is nine-angled, six of the angles being salient, the others retreating, and the suture lines are directed to the middle of the two antero-lateral radials and the anal plate. By this arrangement two of the radials are heptagonal, and the three others hexagonal. In *Compsocrinus* with four basals, the posterior and anterior basals are pentangular, the two others quadrangular, the anterior radial hexangular, all others heptangular.

The alternate bifurcation of the arms from the two main branches of the rays, which is characteristic of the Actinocrinidæ, forms another well-marked distinction between the two families, and is also very constant. Among the Batocrinidæ this mode of bifurcation occurs only in *Gemmaocrinus* from the Upper Devonian, but there it goes along with a second anal; and we must regard this genus as a transition form toward the Actinocrinidæ. The paired arm structure also, although not a constant character, occurs only among the Batocrinidæ; never among the Actinocrinidæ. Another significant fact, tending to confirm the separation of the two groups as distinct families, is that so far as known the Batocrinidæ disappear in Europe with the dawn of the Carboniferous — except perhaps

Megistocrinus, of which a species may possibly exist in the Mountain Limestone of England — and are replaced by the Actinocrinidæ. This is also the case in the western territories of the United States. At Lake Valley, New Mexico, among many hundred Camerate Crinoids collected from the horizon of the Burlington group, we found only one or two straggling Batocrinoids.

The genera for which this family is proposed, with the exception of *Compsocrinus*, have been heretofore referred by us and others to the Actinocrinidæ, and most of the species were originally described under *Actinocrinus*. Even the genus *Batocrinus* was not accepted by the earlier writers. This was no doubt largely due to the fact that Casseday in describing the genus overlooked the arrangement of the plates of the anal area, which, as we think, forms the principal distinction between the two groups. He only alluded to the meeting of the distichals and palmars over the interbrachials, and the separation of the latter from the plates of the ventral disk. The importance of the structure of the anal area was pointed out by us in the Revision, Part II., p. 139, when we recognized the genus *Batocrinus*, but at that time we only made it the type of a subgroup under the Actinocrinidæ.

As now defined, the Batocrinidæ are by far the largest family of the Camerata, and they have a greater stratigraphic range than any except the Rhodocrinidæ, — appearing first in the Hudson River group of the Lower Silurian, and continuing into the Warsaw. The family consists of eighteen genera, of which twelve, so far as known, are restricted to America, and six to Europe; while *Periechocrinus* and *Megistocrinus* occur on both sides of the Atlantic. Of these genera two hundred and three good species have been recognized, — fifty of them coming from Europe and one hundred and fifty-three from North America.

There are in Europe two other genera which probably ought to be placed in this family, — *Polypeltes* Angelin, and *Spyridiocrinus* Oehlert; but as the arrangement of the two or three proximal rings of plates in the calyx cannot be made out in the specimens, they may possibly belong to the Melocrinidæ.

We have subdivided the genera of this family into two sections, which will considerably facilitate identification, viz. :—

A.

Those in which the ventral disk is highly differentiated, the plates being large and heavy, and in which the arms do not branch beyond a minute axillary at the arm opening . . . BATOCRINITES.

B.

Those in which the ventral disk is composed of small, irregularly arranged plates, and the arms generally branch after becoming free . . . PERIECHOCRINITES.

A. BATOCRINITES.

BATOCRINUS CASSEDAY.

1854. CASSEDAY; Zeitschr. der Deutsch. Geol. Gesellsch., Vol. VI., p. 237.
 1857. PICTET; Traité de Paléont., Vol. IV., p. 324.
 1862. DUJARDIN and HUPÉ; Hist. naturelle des Zoophytes Echinod., p. 142.
 1865. MEEK and WORTHEN (Subgenus of *Actinocrinus*); Proceed. Acad. Nat. Sci. Phila., p. 153.
 1866. MEEK and WORTHEN (Subgenus of *Actinocrinus*); Geol. Rep. Illinois, Vol. II., p. 150.
 1869. MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 350.
 1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 364.
 1878. W. and SP.; Proceed. Acad. Nat. Sci. Phila., p. 329.
 1879. ZITTEL; Handb. der Paläontologie, Vol. I., p. 370.
 1881. W. and SP.; Revision Palæocr., Part II., p. 162 (Proceed. Acad. Nat. Sci. Phila., p. 336).
 1885. STEINMANN; Elemente der Paläontologie, Part I., p. 157.
 1890. S. A. MILLER; North Amer. Geol. and Palæont., p. 227.
 1892. S. A. MILLER; Adv. Sheets of the 18th Geol. Rep. Indiana, p. 23.
 Syn. *Actinocrinus* (in part) SHUMARD, HALL, WHITE, MCCHESENEY, and MEEK and WORTHEN prior to 1865, QUENSTEDT as late as 1885.
 Syn. *Uperocrinus* (in part) MEEK and WORTHEN, 1865; Proceed. Acad. Nat. Sci. Phila., p. 153.

Calyx biturbinate to subglobose; the rays not lobed. Plates heavy, the surface more or less convex and frequently nodose, but otherwise not ornamented. Basals three, proportionally large, forming a hexagonal cup thickened at the lower margin, and generally projecting laterally. Radials very large. Costals two, small, quite frequently anchylosed; the first quadrangular, almost linear; the second pentangular. Distichals and palmars as large as, or larger than the costals. Palmars are always represented, except occasionally in the anterior ray. The posterior rays frequently have post-palmars, which do not occur in the other rays. Arm openings equidistant, directed horizontally. Respiratory pores twenty, two above each interradius, and two to each interdistichal space; placed at a somewhat higher level than the arm openings. Arms twenty to twenty-six; in species with more than twenty arms the extra number is divided between the two

posterior rays. The arms are simple, very short, slightly incurving, and rounded on the back (never spatulate); the pinnules stout, deep, closely packed, and flattened at their lateral faces. Interbrachials separated from the interambulacral pieces by the overarching palmars, which form a continuous series around the calyx; the four regular sides have rarely more than three, of which the first is very large, those of the second row being small, while some species have but one. The anal plate is succeeded by three large pieces, and these variously by one, two, or three interbrachial plates. There are neither interdistichals nor interpalmars. Ventral disk convex; the plates of nearly uniform size, except the posterior oral, which is larger, more convex, and forms the base of the anal tube on the anterior side. Anal tube central, heavy and long, often reaching twice the length of the arms. Column stout, round; the axial canal small and pentangular.

Distribution. — *Batocrinus* ranges from the Kinderhook to the lower part of the St. Louis group, and, so far as known, is restricted to America.

Type of the genus: *Batocrinus icosidactylus* Cass.

Remarks. — The genus *Batocrinus* was not accepted by Hall, White, or McChesney, who referred the respective species to *Actinocrinus*. Meek and Worthen were at first inclined to give it only subgeneric rank, but in 1873 recognized it as a full genus, in which they were followed by us in 1881. As the best distinction between *Batocrinus* and *Actinocrinus*, Casseday pointed out the closure of the fixed upper brachials over the interbrachial plates, and no doubt this is a most excellent character, and holds good in the typical species of Casseday. But unfortunately, among the species which Meek and Worthen afterwards referred to the genus, there are quite a number in which this rule does not apply, and these species, which have good generic characters of their own, have been eliminated by us, and made the types of independent genera. *Batocrinus*, as now restricted, differs from *Eretmocrinus* in having short cylindrical arms in place of paddle-shaped ones, and in the greater length of the anal tube. *Eutrochocrinus* and *Dizygocrinus* differ from both of them in the tendency of the arms to double from the same opening. *Macrocrinus* and *Lobocrinus* have the rays lobed and the arms arranged in groups; in the former the anal tube is large and central, in the latter short and excentric. The arms of *Batocrinus* are sometimes slightly flattened towards the tips, but never paddle-shaped like those of *Eretmocrinus*.

Batocrinus icosidactylus CASSEDAY.*Plate XXVII. Figs. 3a, b, c.*

1854. *Batocrinus icosidactylus* — CASSEDAY; Zeitschr. d. Deutsch. Geol. Gesellsch., Vol. VI., p. 238, Plate 2, Figs. 1, 1a-c.
 1857. *Batocrinus icosidactylus* — PICTET; Traité de Paléont., Vol. IV., p. 324, Plate 101, Fig. 6.
 1867. *Actinocrinus (Batocrinus) icosidactylus* — M. and W.; Geol. Rep. Illinois, Vol. V., p. 367.
 1881. *Batocrinus icosidactylus* — W. and Sp.; Revision Palæocr., Part II., p. 166.
 1885. *Actinocrinus icosidactylus* — QUENSTEDT; Handb. der Petrefactenkunde (3te Auflage), Plate 77, Fig. 3.
 1892. *Batocrinus icosidactylus* — S. A. MILLER; Adv. Sheets Geol. Rep. Indiana, p. 24, Plate 4, Figs. 1-5.

Calyx nearly as wide as high. Dorsal cup rarely more than half the height of ventral disk, low saucer-shaped, with a protuberant base; plates heavy, slightly convex, their surface smooth or obscurely granular.

Basal cup projecting conspicuously beyond the level of surrounding plates, almost circular in outline; the median part deeply depressed for the reception of the column; central perforation subpentangular. Radials short, partly hidden from view by the overhanging rim of the basals. First costals quadrangular, three times as wide as long, narrower than the second. Distichals two, a little larger than the costals. Palmars three, increasing in width upward and placed in longitudinal series, which are separated by well defined grooves. Arm openings facing laterally, forming a continuous row around the calyx. Arms four to each ray; their structure not known. Interbrachials three (rarely four) to the interradius; the first much larger than the other two. The anal plate, which resembles the radials, is followed by three plates, and these by one or two. Interbrachials not connected with the plates of the tegmen, the higher brachials being in lateral contact. Ventral disk conical, passing gradually into a strong, almost central tube. The larger plates, as a rule, are extended into thorn-like projections, and are surrounded by smaller, slightly convex pieces. Orals quite excentric, four of them spinous, the posterior one merely convex. The radial dome plates, which are represented by plates of a first, second and third order, are also spiniferous. Anal tube long, heavy, and composed of convex pieces, among which larger thorn-like plates are scattered at intervals. Column round.

Horizon and Locality. — Warsaw limestone; Spergen Hills, Ind., and Barren Co., Ky.

Batocrinus irregularis CASSEDAY.*Plate XXVII. Figs. 4a, b, and c.*

1854. CASSEDAY; Deutsche Geol. Gesellsch., Band VI., p. 240, Plate 2, Figs. 2a, b, c.
 1867. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367.
 1881. W. and SP.; Revision Palæocr., Part II., p. 166.
 1892. S. A. MILLER; Adv. Sheets 18th Rep. Geol. Surv. Indiana, p. 26, Plate 4, Figs. 6-9.

Resembling the preceding species, but readily distinguished by its smaller size, more elongate form, much greater depth of dorsal cup, by having a less number of arms, and the absence of spiniferous plates in the tegmen. Surface of plates smooth or slightly wrinkled, the radial ones transversely ridged; suture lines distinct.

Basal cup projecting, circular in outline, deeply excavated for the attachment of the column. Radials short, considerably wider than the costals. Costals small, quadrangular, twice as wide as long; succeeded in four of the rays by 2×2 distichals, which resemble the costals in form and size, and support $2 \times 2 \times 2$ fixed palmars. In the anterior ray there are two rows of three successive distichals followed by the free arms. Arms eighteen, the ambulacral openings directed horizontally. Interbrachial plates three; the first larger, supporting two plates in the second range. The anal piece is succeeded by three plates, and one above. Tegmen high-conical, higher than the dorsal cup; composed of comparatively few, large, tumid plates. Anal tube stout, almost central; constructed of strongly nodose pieces. Arms and column unknown.

Horizon and Locality. — Same as last.

Batocrinus subæqualis (MCCHESNEY).*Plate XXVIII. Figs. 7a, b; 8a, b, and 9.*

1860. *Actinocrinus subæqualis* — MCCHESNEY, Descr. Pal. Foss., p. 17.
 1870. *Actinocrinus subæqualis* — MCCHESNEY; Chicago Acad. Nat. Sci., p. 13, Plate 5, Fig. 7.
 1873. *Batocrinus subæqualis* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367.
 1881. *Batocrinus subæqualis* — W. and SP.; (Syn. of *Batocrinus discoideus*), Revision Palæocr., Part II., p. 166.
 Syn. *Actinocrinus discoideus* — HALL; 1858, Geol. Rep. Iowa, Vol. I., Part II., p. 594.
 Syn. *Batocrinus discoideus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367, and Whitfield; Mem. Amer. Mus. Nat. Hist., 1893; Vol. I., p. 14, Plate 1, Figs. 19, 20.
 Syn. *Actinocrinus formosus* — HALL, 1860; Suppl. Geol. Rep. Iowa, p. 30.
 Syn. *Batocrinus formosus* — MEEK and WORTHEN; 1873; Geol. Rep. Illinois, Vol. V., p. 367.
 Syn. *Batocrinus æquabilis* — S. A. MILLER, 1894; Geol. Surv. Missouri, Bull. 3, p. 25, Plate 5, Figs. 13, 14, 15.

Calyx somewhat biturbinate, as wide as high. The dorsal cup larger than the ventral disk; sides expanding gradually to the arm bases and forming nearly a straight line. Plates nodose, except the first costals which are generally flat.

Base more than twice as wide as high, hexangular as seen from the bottom; the interbasal suture lines distinctly grooved; column facet deeply depressed. Radials wider than long, widest at two thirds their height, excavated at the upper edges. Costals small, both together very little more than half the size of the radials; the first linear; the second a little longer and wider in the upper part. Distichals two, except in the divisions facing the anal side, in which there is but one, which is axillary. Palmars 2×20 ; but while those approaching the posterior side bifurcate again, the others are followed directly by the free arms. Arm facets concave, arranged in a continuous row around the calyx. Arms twenty-two, short, almost of equal width to their tips. Pinnules closely packed together, long, deep, and flattened at the sides. Regular interbranchials consisting of one large plate, sometimes followed by one or two smaller ones; the former extending to the top of the first distichals and even to the palmars. Anal plate considerably higher than the radials and succeeded by three large plates, and these by a single one. Ventral disk subconical, plates tuberculose, pointed at the top. Orals and first radial dome plates larger than the intervening supplementary pieces, which are quite irregular in form and size. Anal tube very long, sometimes extending several inches beyond the tips of the arms; composed of tumid plates. Column constructed of rather large joints with rounded edges; the internodals somewhat the narrowest.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa, and in rock of the same age in Southern Missouri.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — There is not the least doubt that *Actinocrinus discoideus* and *A. formosus*, both described by Hall, are identical with this species. The former name has priority, but, being described from a crushed specimen, and neither the name nor the description giving a correct idea of the species, we are compelled to adopt McChesney's name. The form described as *Actinocrinus formosus* differs only in the less convexity of the plates.

Batocrinus æqualis (HALL).*Plate XXVIII. Figs. 5, 6.*

1858. *Actinocrinus æqualis* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 592, Plate 11, Figs. 4a, b.
 1873. *Batocrinus æqualis* — M. and W.; Geol. Rep. Illinois, Vol. V., p. 367.
 1881. *Batocrinus æqualis* — W. and Sp.; Revision Paleocr., Part II., p. 165.
 Syn. *Actinocrinus doris* — HALL, 1861; Descr. New Spec. Crin., p. 15.
 Syn. *Batocrinus doris* — M. and W.; Geol. Rep. Illinois, Vol. V., p. 367.

Closely allied to the preceding species, but differing in the greater number of arms. Calyx biturbinate, truncate at the bottom; the dorsal cup a little higher than the ventral disk; the sides abruptly spreading to the arm bases, which are directed horizontally; the plates smooth, highly convex.

Base short, excavated for the reception of the column, the interbasal sutures deeply grooved, giving to the lower end a trilobate outline. Radials smaller than the basals, from once and a half to twice as wide as long. First costals less convex than the surrounding plates, quadrangular, variable in size, sometimes but half the width of the radials and very short. Second costals wider and longer than the first. Distichals 2×2 ; supporting in four of the rays two rows of three plates, and these four arms to the rays. In the two posterior rays, which have from six to seven arms, both outer distichals of the rays support an axillary palmar, which is followed by 2×2 post-palmars; while the two inner distichals support but 2 palmars. When there are seven arms, one of the post-palmars is also axillary and gives off two arms instead of one. Arms short, cylindrical, biserial from their bases; the plates short. Pinnules long. Regular interbrachials two or three, the first very large. The anal area consists of five plates; the anal plate, which is larger than the radials, is succeeded by three plates in the second row, and a small piece above. At all sides the interbrachial plates are separated from the dome plates by the palmars, and post-palmars respectively, which form together with adjoining distichals and costals around the plates of the anal area a well defined semicircle. Ventral disk conical, gradually passing into the anal tube; the plates strong and convex. The orals and ambulacral plates are much larger than the intervening ones, which latter are comparatively small and numerous at the posterior side. Anal tube central, its plates slightly tumid. Column similar to that of the preceding species.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa, and Southern Missouri.

Type in the (Worthen) Illinois State collection, Springfield.

Batocrinus quasillus (MEEK and WORTH.).*Plate XXVIII. Figs. 4a, b.*

1869. *Batocrinus quasillus* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 352; also Geol. Rep. Illinois, Vol. V., p. 369, Plate 5, Fig. 2.
 1881. *Batocrinus quasillus* — W. and SP.; Revision Palæocr., Part II., p. 167 (Proceed. Acad. Nat. Sci. Phila., p. 341).

Height of the calyx equal to its width; the ventral disk occupying fully one half. Dorsal cup wide at the bottom, rapidly spreading near the arm bases, so as to place the upper rows of brachials in a horizontal position. Plates extremely heavy and evenly convex.

Basal cup three times as wide as high, hexagonal, thickened at the lower end; the interbasal sutures slightly indented; the bottom deeply depressed for the reception of the column. Radials nearly twice as wide as long, the upper face concave. First costal very small; the second more than twice as long as the first. Distichals two; followed by two rows of two palmars each, except in the divisions facing the anal side, where the first distichal is axillary and supports an axillary palmar, and this 2×2 post-palmars. Arms twenty-two to twenty-four, arranged at equal distances, openings directed horizontally. Interbrachials two, the upper very small, arched over by the palmars. Anal plate a little narrower and longer than the radials, succeeded by three good-sized plates, and these by a single one. Ventral disk highly convex, inflated near the periphery so that its sides project sometimes beyond those of the dorsal cup. Orals and radial dome plates somewhat tuberculous, and twice as large as the surrounding pieces which are merely convex. Anal tube very strong, composed of thick plates; its length not known.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.
Type in the Museum of Comparative Zoölogy.

Batocrinus lepidus (HALL).*Plate XXVIII. Figs. 2 and 3.*

1860. *Actinocrinus lepidus* — HALL; Suppl. Geol. Rep. Iowa, p. 33.
 1881. *Batocrinus lepidus* — W. and SP.; Revision Palæocr., Part II., p. 167.
 1893. *Batocrinus lepidus* — WHITFIELD; Mem. Amer. Mus. Nat. Hist., Vol. I., p. 16, Plate 1, Figs. 17, 18.

A little larger than the two preceding species. Calyx wheel-shaped, abruptly spreading beneath the arm bases; ventral disk depressed convex, with a central anal tube rising abruptly from the summit. Plates smooth,

convex; the suture lines grooved. Basals short, thickened around their lower margins, and slightly excavated for the attachment of the column. Radials a little wider than long, concave at the upper face. Costals comparatively larger than in the preceding species; quadrangular and pentangular; the second wider than the first. Distichals two (except toward the anal side); the upper wider than the costal axillary; followed by two palmars, of which the second is the larger. Toward the anal side there is but one distichal, and the second palmar at the outer divisions of the rays supports two post-palmars, but only one at the inner side, making five arms to each of the posterior rays. Arm openings arranged at nearly equal distances; directed horizontally. Respiratory pores large, placed a little above the arm bases. Arms heavy, short, slightly flattened on the back; composed of two series of short joints. Interbranchials two; the first extending to the lower sloping faces of the first distichals. The palmars in lateral contact except at the posterior side, where only the post-palmars connect laterally. Anal plate longer than the radials; followed by three and two plates. The plates of the ventral disk vary in size; the orals and radial dome plates being more than twice as large as the intervening pieces, which are quite numerous. Length of anal tube not known.

Horizon and Locality.—Lower Burlington limestone; Burlington, Iowa and Southern Missouri.

Type in the (Worthen) Illinois State collection.

Batocrinus Calvini ROWLEY.

Plate XLVI. Figs. 8a, b.

1890. ROWLEY; Amer. Geologist, Vol. V., p. 146.

Calyx greatly depressed, almost twice as wide as high, with a sharp edge around the margin. Dorsal cup low bowl-shaped, a little higher than the ventral disk. Plates very slightly convex; the suture lines distinct, but not actually grooved.

Basals quite small, forming a pentagon without re-entering angles; the columnar concavity narrow but rather deep. Radials as large as both costals together, wider than high. First costals quadrangular, twice as wide as high; the second pentangular, wider than the first, but narrower than the radials; the upper angle quite obtuse. Distichals larger than the costals; represented in four of the rays by two series of two plates, the upper ones,

which are much wider than the first, supporting 2×2 palmars. The posterior ray has three distichals and no palmars. Arm facets slightly concave, directed obliquely upward; the ambulacral openings small and equidistant, except the one between the posterior rays, which is not only wider but a little indented. Structure of arms unknown. Regular interbranchials one or two, the first large, the second, if present, quite small; roofed by the palmars, except at the anterior side by the upper distichals. The anal plate supports two rows of three plates, of which the middle ones are larger than those at the sides; the upper one rising to the height of the first palmars, and arched over only by the arm bearing plates. Disk rising but little above the upper margin of the cup; composed of highly convex, somewhat tumid plates. The orals and radial dome plates — the latter of a first, second, and third order — larger than the interambulacral plates. Anal tube almost central, rather large at the base.

Horizon and Locality. — Lower part of the Lower Burlington limestone; Louisiana, Mo.

Type in the collection of Prof. Rowley, at Fort Smith, Ark.

Remarks. — This species departs from the typical *Batocrinus* in having but eighteen arms, and in the position of the respiratory pores, which are placed so closely to the ambulacral openings as to appear always confluent with them in the specimens. It approaches *Dizygocrinus* in its general form and the small size of the base.

Batocrinus rotadentatus ROWLEY and HARE.

Plate XLVI. Fig. 7.

1891. ROWLEY and HARE; Kansas City Scient., p. 102, Plate 2, Figs. 17 and 18.

Calyx wider than high, wheel-shaped, the base surrounded by a small rim. Dorsal cup a little constricted above the basals, then curving rapidly outward to the arm bases. Surface of plates smooth, slightly convex.

Basals large, erect, rounded at the lower end, and forming a profound concavity, which is completely filled by the upper stem joints; the suture lines deeply grooved. Radials nearly twice as wide as long, about half the size of the basals, but as large as both costals together; the latter quadrangular and pentangular, respectively. Distichals two, short, the second larger than the first and axillary, except in the anterior ray, which has three distichals and no palmars. The other rays have four arms each, and the axil-

lary distichal supports 2×4 palmars. The arm-bearing plates are very prominent, being separated by deep notches, which give to the rim, as seen in a dorsal or ventral aspect, a strongly dentate outline. Arm openings almost equidistant, directed upward. Arms eighteen, their structure not known. Interbrachials three; the first large, a little wider than long, the two upper ones small. Anal plate somewhat narrower than the radials, followed by three plates, of which the middle one is considerably the largest, and these apparently by three smaller ones. Disk nearly as high as the dorsal cup, the sides but very slightly convex; composed of moderately large, conical plates, among which the orals are readily recognized by their larger size. Anal tube almost central and of moderate size.

Horizon and Locality. — Base of the Lower Burlington limestone; Louisiana, Mo.

Types in the collection of Prof. Rowley.

Remarks. — We regard this species as representing a transition toward *Lobocrinus* and *Eretmocrinus*, and we should not be surprised if it had paddle-shaped arms. It resembles in general form *Lobocrinus æquibrachiatus*, especially the larger specimens, in which the arms show a tendency to grouping into pairs; but the interbrachials are arched by the palmars — or distichals at the anterior side — and consist of but three plates. The species should also be compared with *Eretmocrinus clio* Hall.

***Batocrinus turbinatus* (HALL).**

Plate XXVII. Figs. 5a, b, c.

1858. *Actinocrinus turbinatus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 587, Plate 11, Fig. 1.

1873. *Batocrinus turbinatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367.

1881. *Batocrinus turbinatus* — W. and SP.; Revision Palæocr., Part II., p. 168.

Syn. *Batocrinus letus* MILLER and GURLEY, 1894; Geol. Surv. Illinois, Bull. 3, p. 24, Plate 5, Figs. 10, 11, 12.

Calyx to the base of the anal tube generally as wide as high; the dorsal cup one third higher than the ventral disk. Sides but very little concave, straight from the bottom of the basals to the plates supporting the free arms; the latter plates projecting. Plates throughout the dorsal cup almost flat, their surfaces smooth; the suture lines indistinctly grooved.

Basal cup somewhat obconical, sometimes slightly thickened; lower face concave and projecting over the column. Radials large, once and a half as wide as long, the upper face distinctly concave. First costals transversely

linear, smaller than the second, quadrangular with convex upper and lower faces; the second pentangular, very little wider and longer than the first. Distichals two; the upper one wider than the costal axillary; followed by two palmars in two series except in the division facing the anal side, in which there is but one palmar which is axillary and gives off two post-palmars. At four sides the palmars meet with their fellows of adjoining rays, but at the anal side only the post-palmars. Arm openings equidistant, directed horizontally. Arms twenty-two, short, rounded on the back; composed of two series of moderately long joints, distinctly interlocking. Interradials from one to three; the first very large, slightly elongate; the upper ones, if present, quite small. Anal plate longer than the radials, supporting three and two plates. Ventral disk low hemispherical, the plates convex. The orals and radial dome plates, which are more or less tumid, are separated by numerous small supplementary pieces. Anal tube long, subcentral, constructed of convex pieces.

Horizon and Locality.—Same as last.

Type in the (Worthen) Illinois State collection, Springfield.

Batocrinus turbinatus, var. elegans HALL.

Plate XXVII. Figs. 6a, b.

1858. *Actinocrinus turbinatus*, var. *elegans*—HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 588, Plate 11., Fig. 5.

1881. *Batocrinus turbinatus*, var. *elegans*—W. and Sp.; Revision Palæocr., Part II., p. 168.

More elongate than the typical form; the dorsal cup nearly twice as high as the ventral disk; sides convex from the top of the basals to the arm facets. Basal disk short, distinctly lobed and spreading outward. Radials, costals, distichals, and palmars arranged as in the typical form, but there are quite frequently twenty arms (four to each ray) in place of twenty-two; and the plates forming the arm bases are less projecting.

Horizon and Locality.—Same as last.

Type in the (Worthen) Illinois State collection.

Batocrinus Macbridei W. and Sp.

Plate XXX. Figs. 1, 2, 3.

1887. W. and Sp.; Geol. Rep. Illinois, Vol. VIII., p. 172, Plate 15, Fig. 4, and Plate 17, Figs. 11 and 12.

1890. S. A. MILLER; North Amer. Geol. and Palæont., p. 228, Fig. 253.

The smallest known species of *Batocrinus*. Height of crown not exceeding 3 cm. Calyx about as wide as high, the arm bases projecting. Dorsal cup obconical; sides straight from the bottom to the top of the distichals, thence curving more abruptly outward; base broadly truncate. Plates slightly convex, without ornamentation; suture lines depressed. Color of specimens lighter than that of *Rhodocrinus Kirbyi* and *Dichocrinus inornatus* from the same locality.

Basals short, forming a broad hexagonal disk, which is but very little excavated at the bottom. Radials considerably wider than long; their upper faces concave. Costals small, quadrangular and pentangular; the first convex below, more than twice as wide as long; the second not longer than the first but wider. Distichals 2×10 ; followed by two rows of cuneate palmars, which support the free arms. Arms twenty, comparatively heavy, rounded on the back, the tips slightly incurved and somewhat flattened. Interbrachials three, sometimes with a small one on top; the first extending to the full length of the first distichals, those of the second range arched over by the palmars, except at the posterior side where a narrow piece intervenes between them. The anal plate is followed by three rather large pieces, and these by two and one. The ventral disk is a little lower than the dorsal cup, highly convex, and slightly depressed at the interradi- al and interdistichal spaces; the ambulacra elevated, and covered by several nodose plates of a first and second order. The interambulacral spaces are paved by numerous very small, convex pieces. Orals comparatively small. Anal tube slender, shorter than usual in this genus, extending but little above the tips of the arms. Column short, the nodal joints in the upper part large, rounded at their edges; the intervening joints comparatively short and narrow, contrasting strongly with the nodal ones. Toward the lower end the joints are more uniform. The column has been observed by us to its full length in several specimens, in none of which it measures more than six inches. It generally tapers to its distal end, where it terminates in a sharp point. The lower part, to about one third of its whole length, bears short lateral cirri, which are arranged singly — not in whorls.

Horizon and Locality. — Kinderhook group; Le Grand, Marshall Co., Iowa.

Types in the collection of Wachsmuth and Springer.

Batocrinus poculum MILLER and GURLEY.*Plate XXX. Fig. 6.*

1890. Descr. New Spec. and Gen. of Echinod., p. 34, Plate 6, Figs. 6, 7.

Somewhat larger than the preceding species. Dorsal cup bulging outward, spreading but little above the costals; the base not projecting; plates nearly flat; suture lines obscurely grooved.

Basals short, forming a rounded shallow cup, of which the upper margin is deeply excavated for the reception of the radials. Radials once and a half as wide as long, the suture lines toward the costals concave. Costals large for the genus; the first generally larger than the second. Distichals and palmars two, as large as the costals. Arm openings at right angles to the axis of the calyx. Arms twenty, arranged at equal distances; short, incurving, the tips slightly flattened. Interbranchials three to four, those of the second row comparatively large. Anal plate followed by three or four plates, and these by three others. Palmars in lateral contact apparently at all sides. Ventral disk shorter than the dorsal cup, depressed convex; composed of tumid plates. Anal tube long and heavy. Of the column only the upper part is known, which is similar to that in the preceding species.

Horizon and Locality. — Same as last.

Type in the collection of W. L. E. Gurley.

Remarks. — This form is closely allied to our *Batocrinus Macbridei*, from which it differs in the more globular form of the calyx, in the more flattened and less spreading ventral disk, and in the greater length of the ventral tube.

Batocrinus pistillus (M. and W.).*Plate XXXI. Figs. 4a, b.*1865. *Actinocrinus pistillus* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 152.1868. *Actinocrinus (Batocrinus) pistillus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. III, p. 472, Plate 16, Figs. 4a, b.1881. *Batocrinus pistillus* — W. and SP.; Revision Palæocer., Part II., p. 167.

Calyx subpyriform; the sides of the dorsal cup rising nearly vertically from the base to the summit of the radials, then expanding at first gradually to the distichals, and thence rapidly so as to place the upper palmars and post-palmars in a horizontal position. Plates highly convex; especially the radials, the anal plate, and the first interbranchial pieces, which are transversely nodose.

Basal cup trilobate, more than twice as wide as long, flat at the bottom, a little contracted at the upper end. Radials more than four times as large as the costals, a little wider than long. Costals two, all of nearly equal size, but the first quadrangular, the second pentangular; wider than long. Palmars in two ranges; the upper supporting the free arms, except those next to the anal side, which are axillary and sustain two post-palmars; there being five arms to each posterior ray, and twenty-two to the species. The anal plate is followed by two rows of three plates each, above which the post-palmars meet in lateral contact. At the other interradii the first interbrachials, which are almost as large as the radials, are followed by one or two small pieces arched over by the palmars. Arm openings directed horizontally, arranged at equal distances around the calyx, with a slight depression at the posterior side. Arm structure not known. Ventral disk hemispherical, a little shorter than the dorsal cup; composed of rather large, tuberculous plates of nearly the same size. Anal tube almost central, wide at the base; its length not known.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa. (A rare species.)

Type in the Museum of Comparative Zoölogy.

Batocrinus tuberculatus W. and Sp. (nov. spec.).

Plate XXVIII. Figs. 10a, b.

A very graceful species, rather below medium size. Calyx higher than wide, gradually expanding from the basals to the top of the distichals, and thence more rapidly to the arm bases. Plates of the dorsal cup tuberculous, with well defined sharp nodes in the centre, those of the brachials forming a sort of interrupted obscure ridge.

Basal cup distinctly trilobate, deeply depressed at the interbasal sutures, flanging outward at the lower end, and depressed at the bottom. Radials about as wide as long, with a large transverse node. Costals small, both together very little more than one third the size of the radials; the first smaller than the second, quadrangular; the upper pentangular. Distichals two, followed by three palmars, which support the free arms. Arm bases directed horizontally, forming an uninterrupted line around the calyx. Arms twenty, equidistant, short, rather delicate, flattening at their upper ends, and curving inward; their lateral margins indented, and their backs lined by two

rows of obscure nodes. Interbrachial plates three, consisting of a large tumid plate, followed by two small, slightly convex pieces, above which the three rows of palmars meet those from adjoining rays, except at the posterior side, where only the plates of the upper row are in contact. Anal plate longer than the radials; followed by three and three plates. Ventral disk depressed, greatly inflated above the arm bases; composed almost exclusively of the orals and radial dome plates, which are nodose. Anal tube comparatively slender at the bottom, formed of convex, elongate pieces; its length not known.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Types in the collection of Wachsmuth and Springer.

Remarks. — This species in the construction of the calyx is closely allied to *Batocrinus pistillus*, and in the arm structure resembles some species of *Eretmocrinus*.

Batocrinus clypeatus (HALL).

Plate XXVII. Figs. 8a-e.

1860. *Actinocrinus clypeatus* — HALL; Suppl. Geol. Rep. Iowa, p. 12, Plate 3, Fig. 12.
 1867. *Actinocrinus (Batocr.) clypeatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 150.
 1881. *Batocrinus clypeatus* — W. and SP.; Revision Palæocr., Part II., p. 166.
 Syn. *Actinocrinus papillatus* — HALL; Suppl. Geol. Rep. Iowa, p. 29, Photogr. plates (1872), Plate 3A, Figs. 10 and 11.
 Syn. *Batocrinus papillatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367.
 Syn. *Actinocrinus inornatus* — HALL; Suppl. Geol. Rep. Iowa, p. 24.
 Syn. *Batocrinus inornatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367; and Whitfield, Mem. Amer. Mus. Nat. Hist., 1893, Vol. I., p. 15, Plate 2, Figs. 1-3.
 Syn. *Batocrinus comparilis* — S. A. MILLER, 1892; Adv. Sheets 18th Rep. Geol. Surv. Ind., p. 32, Plate 5, Figs. 18 to 20.
 Syn. *Batocrinus aspratilis* MILLER and GURLEY, 1894; Geol. Surv. Illinois, Bull. 3, Plate 5, Figs. 4, 5, 6.

A very variable species. Calyx a little wider than long; the dorsal cup higher than the ventral disk, convex at the base, the sides concave. Plates from almost flat to moderately convex.

Basals very small, in some cases invisible in a side view. Radials more prominent than any of the other plates, their median portions more or less tumid; they are wider than long and concave at the upper face. Costals quadrangular and pentangular, both together smaller than the radials; the first smaller than the second. Distichals two, as large as the costals, each one supporting 2×2 palmars, which are in contact laterally and support the free arms. Arm openings twenty, arranged at almost equal distances, the interspaces slightly grooved. Arms very short, composed of two series of short

transverse pieces with serrated lateral margins; the tips infolding. The anal plate is a little longer than the radials, and followed by three and two plates. The regular sides have two or three interbrachials, of which the first is large. Ventral disk low hemispherical, the plates more convex than those of the dorsal cup, and almost of uniform size. Anal tube extremely long, attaining in one of our specimens a length of five inches, which is nearly four inches beyond the tips of the arms; it is stout at the base, but very thin at the upper end. Column of less than medium size; the nodal joints a little wider than the others; near the calyx they are short and rounded at the edges, but they gradually grow longer and cylindrical; at four inches from the calyx all the joints are of equal size and of nearly the same height.

Horizon and Locality. — Same as last.

Types in the (Worthen) Illinois State collection.

Remarks. — We have found it utterly impossible to separate Hall's "*Actinocrinus*" *papillatus* and "*Actinocrinus*" *inornatus* from this species, although we took the utmost pains to do so, and had the types for comparison. We have before us over one hundred specimens, which agree in all essential points, but differ more or less in the convexity of the plates and the form of the calyx. The plates in some of them are entirely smooth, in others distinctly convex, and while in some the calyx is much wider than high, width and height are almost alike in others. Miller's *B. comparilis* is identical with the typical form.

Batocrinus grandis (LYON).

Plate XXVII. Figs. 1a, b, and 2a, b.

1859. *Actinocrinus grandis* — LYON; Amer. Journ. Sci., Vol. XXVIII., p. 240.

1885. *Batocrinus grandis* — W. and SP.; Revision Palæocr. Part III., p. 113.

Syn. *Actinocrinus Wachsmuthi* — WHITE, 1880; 12th Ann. Rep. Terr. by Hayden (Author's Edit., p. 162), Plate 40, Figs. 1a, b, and Geol. Rep. Indiana for 1879-80, p. 142, Plate 7, Fig. 6 (not *Actinocrinus Wachsmuthi* White, 1862 = *Actinocrinus scitulus*; nor *Batocrinus Wachsmuthi*, Revision Palæocr., Part II., p. 165).

Larger than the preceding species, and proportionally higher. Dorsal cup gradually expanding from the top of the basals to the top of the distichals, thence abruptly to the bases of the free arms. Plates convex. Radials and distichals covered by transverse nodes, the interbrachial plates by round ones, which grow shorter as they approach the arm regions.

Base broad, decidedly lobed; the plates thickened at the lower end, and slightly projecting laterally; the interbasal sutures deeply grooved. Radials

wider than long, larger than both costals together. Costals nearly equal in size; the first quadrangular, wider than long; the second heptagonal, a little wider than the first. Distichals two, transversely arranged; those of the three anterior rays followed by four to five short palmars, which support the free arms. The palmars of the two lower rows are as large as the distichals and resemble them in form, the upper ones curved like arm plates and smaller. The two posterior rays have five to six arms, — exceptionally seven, — the other rays invariably four. In the two former, either both outer palmars of the second row are axillary, or only the one facing the anal side. Arms long, but comparatively thin; rounded at the proximal end, slightly flattened at the distal one, and composed of two series of transverse pieces united by a zigzag suture, each plate covered with two delicate nodes arranged into longitudinal rows. Interbrachial plates: 1, 2, 1. Anal piece narrower and longer than the radials; followed by three or four plates, and these by four to five others of irregular arrangement. Ventral disk hemispheric; the plates tuberculous and of similar size, except those at the posterior side which are somewhat smaller. Anal tube very long and stout, extending far above the tips of the arms; the plates rather large, pentagonal or irregularly hexagonal, and each one covered with a sharp central node. Column large, the nodal joints angular at their edges, and considerably wider than the intervening ones, which, however, increase in width as they pass downwards.

Horizon and Locality. — Keokuk group; Crawfordsville, Ind.

Types in the Lyon collection.

Remarks. — This species is labeled in several collections *Eretmocrinus magnificus*, which is a totally different species. White's *Actinocrinus Wachs-muthi* is identical with this species.

Batocrinus mundulus (HALL).

Plate XXX. Figs. 4a, b, and 5.

1859. *Actinocrinus mundulus* — HALL; Suppl. Geol. Rep. Iowa, p. 39.

1881. *Batocrinus mundulus* — W. and SE.; Revision Palæocr., Part II., p. 167.

Syn. *Actinocrinus similis* — HALL, 1859; Suppl. Geol. Rep. Iowa, p. 40.

Syn. *Batocrinus similis* — M. and W.; Geol. Rep. Illinois, Vol. V., p. 368.

A small species. Calyx higher than wide; the dorsal cup gradually spreading; its base broadly truncate; the sides straight or a little convex. Radials and brachials marked by transversely arranged, obscure angular

ridges; the margins of the plates beveled, so as to make the suture lines quite distinct.

Basals short, thickened around the lower margins and forming a hexagon; the lower face excavated. Radials wider than long. First costals quadrangular, their length equal to half their width; the second pentangular, often smaller than the first. Distichals 2×2 ; those of the upper row wider and axillary, supporting 2×2 palmars. Arms eighteen to twenty. Sometimes the anterior ray has but two arms, and in place of palmars an additional row of distichals. Arm openings equidistant or nearly so. Arms of medium length, cylindrical, decidedly tapering at their tips. Anal plate a little narrower but longer than the radials, sustaining three and three plates. The first plate of the regular sides quite large, followed by two or three smaller ones, which are arched by the palmars. Ventral disk high, conical; composed of irregular, convex pieces, which pass gradually into the anal tube. The latter is central, stout at the base, but not very long. Column tapering downward, the nodal joints projecting.

Horizon and Locality.—Keokuk group; Keokuk, Iowa and Nauvoo, Ills.

Type in the Illinois State collection at Springfield.

Remarks.—*Actinocrinus similis* Hall is identical with this species, except that it has only two arms in the anterior ray.

Batocrinus cantonensis M. and G.

Plate XXVII. Figs. 7a, b.

1890. MILLER and GURLEY; Journ. Cincin. Soc. Nat. Hist., Vol. XIII. (June), Plate 6, Fig. 9.

A rather small species. Calyx about one third higher than wide; the dorsal cup higher than the ventral disk, broadly truncate at the bottom, and straight or slightly convex at the sides. Radials and brachials extended into well defined transverse angular nodes; the interrarial plates evenly convex; the plates of the tegmen and anal tube distinctly nodose.

Base broad but short, the lower edge sharply angular and indented at the suture; the bottom flat, except the middle part, which is slightly excavated. Radials considerably wider than long, their ridges directed obliquely downward. First costals very short, linear. Second costals pentangular, longer and wider than the first. Distichals 2×2 ; the upper ones axillary, giving off a palmar from each side. The anterior ray generally has no palmars, and in place of them an additional distichal. The palmars are in

contact with one another and with the third distichals of the anterior ray. Arm bases not projecting; the arm openings equidistant. Arms eighteen, of medium length, rather stout, and gradually tapering; composed of rather long joints, which on the back are marked by a short rounded node. Pinules long. Ventral disk constructed of irregularly arranged nodose plates; and similar plates form the walls of the anal tube, which is comparatively strong and extends beyond the tips of the arms. Column tapering downward; the nodal joints with crenulated edges, and rather long; the inter-nodal joints quite narrow.

Horizon and Locality. — Keokuk group; Canton, Ind.

Type in the collection of W. F. E. Gurley.

Remarks — Miller and Gurley describe this species as having four arms in the anterior ray. This must be exceptional, for seven of our specimens show distinctly but two arms in that ray, and eighteen to the specimen.

Batocrinus laura (HALL).

Plate XXIX. Figs. 5a, b, c, d.

1861. *Actinocrinus laura* — HALL; Prelim. Descr. New Crinoids, p. 15.

1881. *Batocrinus laura* — W. and SP.; Revision Palæocr., Part II., p. 167.

1893. *Batocrinus laura* — WHITFIELD; Mem. Amer. Mus. Nat. Hist., 1893, Vol. I., p. 17, Plate 1, Figs. 15, 16.

Syn. *Batocrinus scyphus* MILLER and GURLEY, 1894; Geol. Surv. Illinois, Bull. 3, p. 23, Plate 5, Figs. 7, 8, 9.

Calyx generally higher than wide, biturbinate. Dorsal cup gradually and uniformly expanding to the arm bases, its sides straight or slightly concave; the plates flat and smooth. Basals not projecting laterally, forming a short conical cup, rounded at the lower edge. Radials a little wider than long, their upper faces concave. First costals less than half the size of the radials, quadrangular, once and a half as wide as long, the lower face convex. The second smaller than the first, pentangular. Distichals 2×2 , larger than the costals; the second larger than the first and twice as wide as long. The upper supports 2×2 palmars, of which the second is deeply excavated, and forms a horse-shoe-shaped facet for the reception of the arms. Arm openings large, directed obliquely upwards; equidistant. Arms rather stout, of moderate length, rounded on the back. Interbrachials: 1, 2, and 1. The anal plate is followed by 3, 3, and 1 plate, arched by the palmars. Ventral disk lower than the dorsal cup, more or less conical; plates almost flat, except the posterior oral, which is somewhat convex. Anal tube central, of

medium size; extending beyond the tips of the arms. Structure of column unknown.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Batocrinus laura, var. **sinuosus** (HALL).

1860. *Actinocrinus sinuosus* — HALL; Suppl. Geol. Rep. Iowa, p. 27. Photogr. plate (1872) 3 A, Figs. 8 and 9.
 1873. *Batocrinus sinuosus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 368.
 1881. *Batocrinus sinuosus* — W. and SP.; Revision Palæocr., Part II., p. 168.

This form is so closely allied to *Batocrinus laura* that we regard it a variety of that species. It is said to differ in having a more pointed base, a deeper groove between the two posterior rays, and that the interbrachials of the anal side pass into the interambulacral plates, thereby approaching *Lobocrinus*. The anal tube is moderately large and almost central.

Horizon and Locality. — Same as last.

Type in the Illinois State collection at Springfield.

ERETMOCRINUS LYON and CASS.

1859. LYON and CASSEDAY; Amer. Journ. Sci. and Arts, Vol. XXVIII. (ser. 2), p. 241.
 1866. SHUMARD (subgenus of *Actinocrinus*); Catalogue Palæoz. Foss. Part I., p. 369.
 1869. MEEK and WORTHEN (subgenus of *Batocrinus*); Proceed. Acad. Nat. Sci. Phila., p. 350.
 1873. MEEK and WORTHEN (subgenus of *Batocrinus*); Geol. Rep. Illinois, Vol. V., p. 368.
 1878. W. and SP.; Proceed. Acad. Nat. Sci. Phila., p. 235.
 1879. ZITTEL (subgenus of *Actinocrinus*); Handb. der Palæontologie, Vol. I., p. 370.
 1881. W. and SP.; Revision Palæocr., Part II., p. 170 (Proc. Acad. Nat. Sci. Phila., p. 344).
 1885. W. and SP.; Revision Palæocr., Part III., p. 113 (Proc. Acad. Nat. Sci. Phila., p. 335).
 1890. S. A. MILLER; North Amer. Geology and Palæont., p. 242.
 Syn. *Actinocrinus* (in part), HALL 1860 and 1861.

Calyx more or less depressed, broadly truncate at the base; plates flat or nodose, the surface sometimes granulated, but generally smooth. Basals short, forming a broad rim, which projects conspicuously outward. Radials as large as or larger than both costals together. Costals two, short, wider than long; the first quadrangular; the second pentangular or exceptionally heptangular. The higher brachials in contact laterally, and forming a continuous ring around the calyx. Arm facets directed horizontally; the ambulacral openings arranged in groups; respiratory pores well defined. Arms from twelve to twenty-six. When there are more than twenty, the addition is made in the posterior rays, the other rays having four each. In species with less than twenty arms, the anterior ray has the least number. Species with sixteen arms always have three in the posterior rays. The arms are paddle-shaped, narrow and rounded in the lower parts, broad and

flattened above; they are biserial, long, and incurving, — their tips sometimes descending to the top of the calyx, — and are composed at their bases of short transverse pieces, which gradually increase in length and width upward. Interradials not numerous, there being from one to three plates at the regular sides, and from four to seven at the anal side including the anals. Ventral disk distinctly asymmetrical, somewhat bulging and higher toward the anterior side, rather flattened posteriorly. Posterior oral conspicuous, large, and central in position; the anal tube excentric and often curving outward. Column round; the axial canal small and pentangular.

Distribution. — Restricted to the Burlington limestone and Keokuk group, and, so far as known, confined to America.

Type of the genus: *Eretmocrinus magnificus* Lyon and Cass.

Remarks. — Meek and Worthen treated *Eretmocrinus* as a subgenus of *Batocrinus*, and added several forms which do not belong to it. It differs from *Batocrinus* in the broad, truncated, and projecting basals, the long, paddle-shaped, and incurving arms, their arrangement, the asymmetry of the ventral disk, and in the excentric position of the anal tube, — all of which are good distinctive characters.

***Eretmocrinus magnificus* LYON and CASS.**

Plate XXXVII. Fig. 3.

1859. LYON and CASSEDAY; Amer. Journ. Sci., Vol. XXVIII., p. 241.

1881. W. and SP.; Revision Palæocr., Part II., p. 173.

(Not *Eretmocrinus magnificus* QUENSTEDT; Handb. der Palæont. (Auflage 3), Plate 77, Fig. 11 = *Batocrinus grandis*).

Syn. *Eretmocrinus lyonanus* S. A. MILLER; Adv. Sheets 17th Geol. Rep. Indiana, 1891, p. 59, Plate 10, Figs. 3 and 4.

Calyx higher than wide, biturbinate; the dorsal cup frequently shorter than the ventral disk; broadly truncate at the base; the sides concave, spreading abruptly near the arm bases. The radials and brachials in well-marked specimens are keel-shaped, with a prominence or node in the centre of each plate, in others they are simply convex; the interbrachial plates, in most of the specimens, are perfectly flat.

Base short, extended into a broad rim, which projects considerably beyond the radials; it has a shallow depression at the bottom, and a somewhat deeper one for the reception of the column, which occupies less than half the diameter of the lower face. Radials more than twice as wide as long. First costals quadrangular, about half the size of the radials; the

second pentangular, their sloping upper faces placed at right angles. Distichals two, the axillary considerably wider. Palmars three, shorter than the distichals, in contact laterally, and so arranged that the salient angle of one plate rests within the retreating angle formed by the two adjoining pieces. Arm openings directed horizontally, arranged in groups, the interspaces between the rays being wider than the others. Arms twenty, exceptionally twenty-two, when there are five in the two posterior rays. According to Lyon and Casseday, the arms are four inches long, subcylindrical to one third their length, when they flatten and expand upwards, reaching at midway a width of half an inch, and a depth of one sixteenth, but higher up their width is reduced to one half, and they end in a rounded edge. The arms are biserial above the first or second free plate. The plates are short near the calyx, but increase in length upward. Interradials two to three; the first rising to one half the height of the first distichals. The anal interradius has six plates above the anal, arranged in two rows. Ventral disk high-conical, surmounted by a small, almost central anal tube; the plates large and tumid.

Horizon and Locality. — Keokuk group; Clear Creek, Hardin Co., Ky.; New Ross, Montgomery Co., Ind.; Pilot Knob, near Louisville, Ky.; and White's Creek Springs, near Nashville, Tenn.

Type in the collection of the late S. A. Casseday.

***Eretmocrinus ramulosus* (HALL).**

Plate XXXVII., Figs. 4a, b, and 5 a, b, c, d.

1858. *Actinocrinus ramulosus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 615, Plate 15, Fig. 7.

1881. *Eretmocrinus ramulosus* — W. and SP.; Revision Palæocr., Part II., p. 173.

Not *Eretmocrinus ramulosus* W. and SP.; 1873, Proceed. Acad. Nat. Sci. Phila., p. 236 = *Eretmocrinus remibrachiatus*, var. *expansus*.

The largest species of this genus. In its general aspect closely resembling *E. magnificus*, but more rugose; the ridges and nodes more prominent; the base narrower; the ventral disk larger, and hemispherical instead of conical; the anal tube much smaller, being reduced to the minimum. Dorsal cup short, rapidly spreading, truncate at the base. Plates elevated and covered with sharp central tubercles; those upon the radials and brachials confluent, forming undulating angular ridges, which branch upon the axillaries and pass into the arms, producing deep depressions between the various divisions of the rays. The radials and brachials have two addi-

tional nodes, one to each side, of which those upon the radials are connected with the central node by a transverse ridge.

Basal ring slightly projecting laterally, more or less notched at the sutures, and moderately excavated at the bottom. Radials twice as wide as long; their transverse ridges pointing downward, sometimes reaching as low as the truncated lower end of the basals. First costals one third smaller than the radials; quadrangular. Second costals generally a little wider than the first, and of about the same length. Distichals two, shorter than the costals. Palmars short, in rows of three, except in the posterior rays, in which the subdivision next to the anal interradius, and in large specimens frequently also that next to the antero-lateral rays, has two palmars followed by three post-palmars. Arms twenty to twenty-four; they are at the proximal end narrow and subcylindrical, biserial from the first free plate, and composed of moderately long pieces. The arms have not been found in position; there are found, however, along with the calyces, detached pieces of *Eretmocrinus* arms, which probably belong to this species. They are more robust than those of the preceding species, not as wide, and their increase in width is more gradual; their cross-section is semi-oval, the dorsal face flat and covered with four rows of nodes, of which two are close to the suture line, and one to each outer border. Interbranchials three; the first large, reaching to nearly the full height of the first distichals; the two others smaller and roofed by the palmars. The anal plate is followed by three large plates, and these by three smaller ones, which are arched by the post-palmars. Ventral disk bulging, larger than the dorsal cup; the plates large, of almost uniform size, and tumid. Anus excentric, very small, sometimes scarcely projecting over the general surface. Column unknown.

Horizon and Locality.—Keokuk group; Keokuk and Augusta, Iowa; Nauvoo, Ills., and White's Creek Springs, near Nashville, Tenn.

Type in the (Worthen) Illinois State collection.

***Eretmocrinus remibrachiatus* (HALL).**

Plate XXXVII., Figs. 2a, b.

1861. *Actinocrinus remibrachiatus*—HALL; Prelim. Notice of New Species of Crinoids, p. 11.

1872. *Batocr. (Eretmocrinus) remibrachiatus*—HALL; Bull. L., N. Y. State Museum Nat. Hist., Plate 4, Figs. 8, 9.

1881. *Eretmocrinus remibrachiatus*—W. and SF.; Revision Palæocr., Part II., p. 173.

Calyx biturbinate, about as wide as high. Dorsal cup obconical, truncate at the base; the sides slightly concave, spreading uniformly to the top of the

costals, and thence abruptly to the arm bases, which stand out horizontally, forming a projecting rim. The radial plates are somewhat elevated or rounded, while the other plates of the dorsal cup are flat and without ornamentation. Suture lines indistinct.

Basal cup short, cylindrical, wider than the column, and very little concave at the bottom. Radials twice as large as both costals together, their upper faces concave. Costals of about equal size, transversely arranged; the first quadrangular; the second pentangular. Distichals 2×10 , resembling the costals in form and size. Palmars 2×20 in the calyx; subquadrangular, and in contact laterally. Arm facets lunate, directed outward, the respiratory pores small, and placed at the sides of the ambulacral openings. Arms four to the ray, exceptionally two in the anterior one; they are very long, broadly paddle-shaped, and biserial from the second free plate. To nearly two inches from the calyx, they are rather thin and cylindrical, whence they grow perfectly flat, and increase rapidly to the width of eight to nine mm., which is slightly reduced toward the extremities. The flat portions are thickest along the median line, the sides being knife-like with serrated edges, which turn slightly outward. At two-thirds their height, the arms generally curve inward until their tips touch the calyx. The proximal arm plates are quite short, but the plates increase to twice their former length as they widen. Pinnules long, composed of long, flat joints. Interradials, 1, 2, 1; the first very large, reaching the top of the distichals. The anal plate is followed by three and two plates. Ventral disk conical, somewhat bulging, often higher than the dorsal cup. The plates are highly convex or conical, and of nearly uniform size. Anal tube slightly excentric, rather short and slender. Column small.

Horizon and Locality. — Upper Burlington limestone, Burlington, Iowa.

Types in the University Museum at Ann Arbor, Mich.

Remarks. — Professor Hall's description of this species is so indefinite that little can be made out of it, and if it were not for his figures, which he distributed privately among some of his collaborators eleven years later, the species could not be distinguished from several others which occur in the same locality. He gives the number of arms as sixteen; stating, however, that there were imperfections in his specimen. Either Hall described one species and figured another, or the number of arms given is erroneous.

Eretmocrinus remibrachiatus, var. **expansus** W. and SP. (nov. var.).

Plate XXXVI. Fig. 1; Plate XXXVII. Figs. 1a, b, and Plate XLIV. Fig. 9.

Butocrinus (Eretmocrinus) remibrachiatus (in part) — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 370, Plate 10, Fig. 5.

Eretmocrinus ramulosus (in part) — W. and SP.; 1878, Proceed. Acad. Nat. Sci. Phila., p. 236, and 1881, Revision Palæocr., Part II., p. 173.

Syn. *Eretmocrinus casedayanus* MILLER and GURLEY, 1894; Illinois Geol. Surv., Bull. 3, p. 17, Plate 3, Fig. 1.

Larger than the typical form; the ventral disk more bulging and comparatively higher; the plates more tumid; the anal tube shorter and more slender; the costals proportionally larger, the second frequently hexagonal or heptagonal owing to the comparatively small size of the first interbrachial. The palmars of the two posterior rays in the subdivision next to the anal interradius consist of but one plate, which is axillary and supports two post-palmars, thus giving to those rays five arms in place of four. The arms at their widest parts sometimes reach a width of from 18 to 20 mm.; they are in the majority of specimens spread out horizontally to one half their length, when they curve abruptly upward and inward, and fold back in a straight line to the calyx, forming a flat, circular disk, in which the serrated edges of the arms frequently interlock with those of adjoining arms.

Horizon and Locality. — Burlington and Keokuk Transition bed; near Burlington, Iowa, and Henderson Co., Ills.

Types in the collection of Wachsmuth and Springer.

Eretmocrinus granuliferus W. and SP. (nov. spec.).

Plate XXXIV. Figs. 5a, b, c.

This species has its closest affinities with *E. remibrachiatus*, from which, as well as from all other species of this genus, it differs in its unique ornamentation. While in that species the plates are flat and perfectly smooth, they are here slightly convex, and the whole dorsal cup is covered by irregular but distinct granules or small nodes, densely crowding the surface. There are no ridges or striæ either on the radial or interrarial plates. Dorsal cup wider than high, rapidly spreading from the top of the basals to the arm regions.

Base broadly truncated, expanding laterally into a broad trilobate rim, flat at the bottom except in the middle, which to one third the width of the

lower face is slightly excavated for the reception of the column. Radials large, twice as wide as long. First costals by one half narrower and shorter than the radials, quadrangular; the second pentangular, wider than the first. Distichals two; the upper one axillary, giving off from each side two large palmars, which support the arms. Arms twenty, four to each ray; long, incurving and biserial; at their bases they are somewhat angular on the back, but at an inch from the calyx they gradually flatten and increase in width, reaching at half length their greatest diameter—8 to 9 mm.—which they retain a short distance, and become reduced to 5 or 6 mm. at the tips. The sides of the arms are knife-like, with dentate edges, the median portions considerably thickest. The arm plates increase in length upward from 1 to 3 mm. Interradials three, in two rows; the anal plate is succeeded by three and two pieces. Ventral disk high, conical, passing gradually into the ventral tube, which is rather long and stout. The plates of the tegmen, including those of the ventral tube, are strongly tuberculous.

Horizon and Locality.—Keokuk group; Indian creek, Montgomery Co., Ind., and Canton, Ind.

Types in the collection of Wachsmuth and Springer.

Eretmocrinus minor W. and Sr. (nov. spec.).

Plate XXXVI. Figs. 10a, b.

Calyx subpyriform, higher than wide. Dorsal cup constricted at the basiradial sutures, thence expanding moderately with straight sides to the arm bases. Ventral disk semiovoid, slightly inflated at the anterior side, the posterior side somewhat depressed. The plates of the dorsal cup perfectly flat and smooth, those of the tegmen a little convex.

Base broadly truncate, moderately high, slightly expanding downward, the lower edges sharply angular, the bottom flat and hexangular. Radials nearly twice as wide as long, the upper face concave. Costals comparatively large; the first quadrangular, a little shorter and considerably narrower than the radials, their upper and lower faces convex; the second wider than the first and heptangular, the sides abutting against the second row of interbrachials. Distichals three in the anterior ray, supporting two arms; in the other rays one division has three distichals, the other but two, of which the upper one is axillary, giving off a palmar from each side. Occasionally one or both antero-lateral rays have four arms in place of three. Arm facets

rather deeply concave, directed outward. Ambulacral openings arranged in groups, the spaces between the posterior rays wider than those between the other rays. Respiratory pores large, arranged in five pairs interradian in position. Arms twelve to fourteen, incurving, extremely heavy for the size of the species; they are biserial from the second free plate, rounded on the back in the lower portions, but flat and spatulate above, reaching a width of three times the diameter at the base. In the rounded part, the back of each alternate plate in both series is covered by a small node, which does not extend to the flattened portions; the arms are keel-shaped, heavy along the median line, and knife-like at the edges. Interbranchials three to four in the four regular rays; the first large and wider than high; the upper smaller and arched by the arm-bearing branchials. At the posterior side the anal is followed by three and two pieces. The ventral disk consists of but few plates, of which the posterior oral is the largest; it is slightly convex, central in position, and bends upward, forming a part of the ventral tube; the other orals and radial dome plates are somewhat nodose. Anal tube excentric, large at the base, and curving to one side.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Types in the collection of Wachsmuth and Springer.

Eretmocrinus depressus W. and Sp. (nov. spec.).

Plate XXXVI. Figs. 11a, b.

Near *Eretmocrinus remibrachiatus*, but the proportions of the calyx quite different; the ventral disk comparatively shorter and less bulging; the bottom of the dorsal cup considerably broader, and the arm openings directed obliquely upwards in place of horizontally. The dorsal cup spreads moderately from the top of the basals to the top of the distichals, thence abruptly to the arms; its height is equal to one third its width at the arm bases; the rays are indistinctly lobed. The plates vary from almost flat to distinctly convex; they are without ornamentation, and the suture lines are obscure.

Base extended outward, forming a broad, projecting rim with a sharp edge at the lower border; its lower face almost flat, and only one third of its width is occupied by the column. Radials comparatively small, a little wider and somewhat longer than the costals; the latter quadrangular and pentangular. Distichals two, the upper one axillary, giving off from each side two short palmars supporting four arms; the anterior ray exceptionally

has but two arms, and an additional distichal in place of the palmars. Arm openings almost equidistant; the space between the two posterior rays somewhat wider and more deeply grooved than those between the other rays; structure of the arms unknown. Interbrachials one and two, arched by the palmars. Anal plate higher than the radials; it supports three plates, of which the middle one is the longest, and is followed by an elongate piece, which rests between the palmars. Ventral disk shorter than the dorsal cup, depressed conical; the plates convex. Posterior oral central, three or four times as large as any other plate of the tegmen, and strongly nodose. Anal tube excentric and small.

Horizon and Locality.—Upper Burlington limestone, Burlington, Iowa.

Types in the collection of Wachsmuth and Springer.

Eretmocrinus clio (HALL).

Plate XXXVI. Figs. 2a, b, and Plate XXXVII. Figs. 9a, b.

1861. *Actinocrinus clio* — HALL; Prelim. Descr. New Crinoids, p. 1, and Boston Journ. Nat. Hist., Vol. VII, p. 262, Photogr. Plate 4, Fig. 7 (1872, N. York State Bull. No. 1).

1881. *Eretmocrinus clio* — W. and Sr.; Revision Palæocr., Part II., p. 172.

Considerably below medium size. Calyx a little higher than wide, gradually and uniformly expanding from the base to the top of the distichals, thence spreading somewhat more rapidly to the arm bases; ventral disk depressed hemispherical, about one fifth shorter than the dorsal cup. Plates from almost flat to moderately convex; the first radials and anal plate a little nodose.

Base higher and narrower than usual in this genus; slightly thickened at the lower margins, and produced into a rim, which is rather deeply excavated at the bottom, and extends beyond the upper limits of the column. Radials proportionally large, almost as long as wide, the lateral faces longer than any of the others. First costals small, quadrangular, a little wider than long. Second costals wider but not longer. Distichals one, large, axillary; supporting two ranges of palmars with four arms, except in the anterior ray which has but two arms supported by two series of three distichals. Palmars in contact laterally with one another and with the upper distichals of the anterior ray, so as to form with them a continuous ring; the arm-bearing plates protruding, and rounded on the back. Ambulacral openings facing outward, equidistant, except on the posterior side, where the interspace is larger and slightly depressed. Arms long and incurving, slender and rounded

in the lower portions, flattened and broader above, increasing gradually to three times their width at the base. They are composed of a double series of short pieces, and are provided along their outer sides with small nodes, which in the flattened portions turn into short spines. Near the calyx every plate is spine-bearing, but higher up only each second or third. Regular interbrachials from two to four, arranged in the usual way, the anal side has three in the first, and two or three in the second row; the anal plate generally a little smaller than the radials. The ventral disk is composed of slightly nodose plates, its anterior side higher than the posterior, the posterior oral prominent. Anal tube subcentral and slender. Column rather stout, the nodal joints considerably wider and longer than the intervening ones, and angular at their edges.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Types in the University Museum at Ann Arbor, and in the collection of Wachsmuth and Springer.

***Eretmocrinus neglectus* MEEK and WORTHEN.**

Plate XXXVI. Fig. 3.

1868. *Batocrinus (Eretmocrinus) neglectus* — MEEK and WORTHEN; Proc. Acad. Nat. Sci. Phila., p. 355.
 1873. *Batocrinus (Eretmocrinus?) neglectus* — M. and W.; Geol. Rep. Illinois, Vol. V., p. 377, Plate 5, Figs. 3a, b.
 1877. *Batocrinus neglectus* — S. A. MILLER; Amer. Palæoz. Foss., p. 72.
 1881. *Eretmocrinus neglectus* — W. and SP.; Revision Palæocr., Part II., p. 173.
 1890. *Eretmocrinus neglectus* — S. A. MILLER; North Amer. Geol. and Palæont., p. 243.

Of the type of *E. clio*. Calyx higher than wide; the dorsal cup inversely campanulate; the sides expanding gradually from the base to the distichals, thence curving more rapidly to the upper edges of the arm-bearing plates, which are slightly grooved but in contact all around; the plates regularly convex, especially the radials, first interbrachials, and the anal plate.

Radials comparatively large, almost as long as wide. First costals quadrangular, a little wider than long; the second frequently heptangular, wider than the first but not longer. Distichals one, large, axillary; supporting two short palmars and four arms in each ray, unless the anterior ray, which is quite often the case, has but two arms, when the large distichal is followed by two smaller. Arm facets small, facing outward. Respiratory pores almost as large as the ambulacral openings; they occupy the lower end of narrow, well defined longitudinal grooves, which extend up into the tegmen for quite a distance. Arm structure unknown. Interbrachials generally three, except

at the posterior side, where there are three in the first row, and two or three in the second. Ventral disk never as high as the dorsal cup, and in some specimens fully one fourth smaller. Posterior oral and radial dome plates more prominent and larger than the surrounding plates. Anal tube moderately large and subcentral.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Types in the Museum of Comparative Zoölogy.

Eretmocrinus calyculoides (HALL).

Plate XXXIV. Figs. 1a, b, 2, 3, 4.

1860. *Actinocrinus calyculoides* — HALL; Suppl. Geol. Rep. Iowa, p. 17; Photogr. Plate 3a, Figs. 2, 3, 4 (N. York State Bull. No. I).
 1873. *Batocrinus (Eretmocrinus) calyculoides* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 368.
 1881. *Eretmocrinus calyculoides* — W. and SP.; Revision Palæocr., Part II., p. 172.

Calyx below medium size, depressed subpyriform, as wide as high. Dorsal cup obconical, truncate at the base, the sides gradually expanding from the top of the basals to the height of the first palmars, whence it spreads abruptly outward so as to place the arm bases at right angles to the diameter of the calyx. Plates flat, the surface devoid of ornamentation, and the suture lines obscure.

Base short, slightly lobed; the lower end somewhat projecting and forming a sharp edge; the lower face flat, except the median part which is moderately excavated for the reception of the column. Radials almost twice as large as both costals together, nearly as long as wide; the upper face concave. Distichals 3×2 in the anterior ray, and two arms; the other rays have 2×2 distichals, followed by two palmars and four arms. Palmars in contact laterally, very short, and curved like free arm plates, having a deep sulcus at each side. Arm facets proportionally large, lunate, directed outward, and arranged in groups, there being wider interspaces between the rays than between their subdivisions. Arms long, incurving, and biserial from their bases up. To the height of about 3 cm. they are subcylindrical, when they grow flat and widen gradually, reaching at two thirds their height a width of about 6 to 7 mm., which in the upper portions is reduced again to 3 mm. The arms in the flattened parts, up to their tips, are knife-like, sharp at both sides, and serrated along the edges; the plates are short near the calyx, but increase to more than twice their length as the arms flatten out. Interradials three, in two rows, except at the posterior

side, where the anal plate is followed by three and two pieces. Ventral disk higher than the dorsal cup, distinctly bulging at the anterior side, and hence shorter at the posterior. The plates flat and smooth, except the posterior oral which is sometimes slightly convex, and is strictly central in position. The ventral tube is excentric, bending obliquely upwards, so as to pass out frequently from between the arms. It is composed of thick, tumid pieces, heavy throughout, stoutest at midway, and obtusely pointed at the upper end, where there is a small aperture. Column small, the upper joint occupying but one third the width of the basal disk.

Horizon and Locality.—Upper Burlington limestone; Burlington, Iowa, Henderson Co., Ills., and Sedalia, Mo.

Types in the (Worthen) Illinois State collection, and in the Museum of Comparative Zoölogy.

Remarks.—This species is readily distinguished by the bulging and asymmetrical form of the ventral disk, the stout, inflated and curving anal tube, and by the form of the arms, which widen more gradually than in any of the preceding species.

***Eretmocrinus calyculoides*, var. *nodosus* W. and Sp. (nov. var.).**

Plate XXXIV. Figs. 6, 7, 8.

The specimens for which we propose this variety differ from *Eretmocrinus calyculoides* in having transverse angular nodes on all radial plates, and rounded nodes upon the interrarial ones. Its general form is somewhat more elongate, less spreading near the arm bases, the radials are proportionally smaller, the ventral disk less bulging; it generally has twenty arms, and these do not attain the same width in the flattened portions. In all other respects it agrees with the typical form.

Horizon and Locality.—Upper Burlington limestone; Pleasant Grove, Iowa.

Types in the collection of Wachsmuth and Springer.

***Eretmocrinus matuta* (Hall).**

Plate XXXVII. Figs. 6a, b, c.

1861. *Actinocrinus matuta*—Hall; Prelim. Descr. New Spec. Crin., p. 14.

1873. *Batocrinus* (*Eretmocrinus*) *matuta*—MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 368.

1881. *Eretmocrinus matuta*—W. and Sp.; Revision Palæocr., Part II., p. 173.

Calyx small, subclavate, longer than wide. Dorsal cup once and a half as high as the ventral disk, expanding but little from the top of the basals

to the foot of the palmars; the latter slightly projecting outward. Surface of plates elevated; the radials raised into conspicuous transverse nodes; the brachials keel-shaped, forming angular ridges, which branch to the bases of the arms; the first interbrachials tumid, the succeeding ones almost flat.

Base moderately high, notched at the sutures; the lower edges projecting laterally, and forming a well defined rim; the bottom rather deeply excavated for the reception of the column. Radials very large, three times as wide as the first costals; the latter unusually small and quadrangular; the second costals somewhat larger and pentangular. Distichals 2×2 , of the size of the costals. Palmars 2×4 , in contact laterally, except at the posterior side where they are generally separated by a small interbrachial piece. Arm openings nearly equidistant, only the space between the two posterior rays being a little the widest and slightly depressed. Arms long, slender, incurving, subcylindrical to one third their length, then gradually flattening and expanding to once and a half their lower width; their sides knife-like and serrated along the edges. Interradial spaces somewhat depressed; the first interbrachial very large, supporting two small plates in the second row. Anal plate a little higher than the radials, and formed into a circular node instead of a transverse one; followed by three, two, and one plate. Ventral disk hemispherical, somewhat bulging toward the sides. Plates large and slightly convex. Between the plates at the periphery there are upon the surface narrow but deep vertical grooves, which lead to the respiratory pores. The pores are large and arranged in the usual manner. Anal tube excentric, very long, stout, retaining the same width to near its upper end, where it tapers rapidly and is pierced by a minute opening. At about half its length, it curves abruptly at right angles, and passes out laterally between the sides of the arms. Column moderately large, composed near the calyx alternately of thicker and thinner joints.

Horizon and Locality. — Lower part of the Upper Burlington limestone, Burlington, Iowa.

Types in the University Museum at Ann Arbor, and in the Museum of Comparative Zoölogy.

Remarks. — The peculiar structure of the anal tube, to which we allude in the description, occurs in all our specimens, and has been observed also in a fine specimen in the Museum at Cambridge.

Hall, in his Preliminary Descriptions of New Crinoids, p. 14, mentions a form to which he applied the name *Actinocrinus matuta*, var. *attenuata*; but

as no figure is given, and the description is insufficient for identification, we are compelled to ignore it for the present. Even the figure given by Whitfield (Mem. Amer. Mus. Nat. Hist. N. York, Plate 1, Figs. 23 and 24), made from a weathered specimen, does not aid us in distinguishing the form.

Eretmocrinus clælia HALL.

Plate XXXVI. Figs. 4a, b.

1861. *Actinocrinus clælia* — HALL; Prelim. Descr. of New Spec. of Crin., p. 1, and Bost. Journ. Nat. Hist., Vol. VII, p. 266.
 1873. *Batocrinus (Eretmocr.) clælia* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 368.
 1881. *Eretmocrinus clælia* — W. and SP.; Revision Palæocr., Part II., p. 173.

A little larger than the preceding species. Calyx about as high as wide, broadly truncated at the bottom, the sides of the dorsal cup gently expanding to the arm bases. Plates spinous, subspinous or nodose; the suture lines slightly depressed.

Base short; the plates distinctly angular at their upper faces; the bottom broadly truncate and perfectly flat, except the central part which is slightly excavated for the reception of the column; the suture lines deeply grooved. In some specimens there is a longitudinal groove following the median line of the basals, which makes the base appear hexapartite, especially if the respective parts, as in some cases, are extended outward into spines. Radials of moderate size, wider than long, the upper face concave, the surface covered with a transverse spine or node. Costals rather large; the first quadrangular, convex at the upper and lower faces; the second a little wider and pentangular. Distichals two or three. The anterior ray, when with but two arms, has three distichals, the two antero-lateral rays — sometimes also one or both posterior rays — only two, and the upper plate supports two short palmars. In the majority of specimens, both posterior rays have but three arms, and only the distichals next to the anal side bear palmars. The brachials throughout the calyx are provided with a sharp node or short spine; the plates of the two upper rows are in contact laterally. Arm facets large, lunate, and directed laterally; the ambulacral openings arranged in groups, the interspaces between the rays being larger than those between their subdivisions. Respiratory pores large. Arms sixteen to eighteen, stout, rather long, and incurving. Near the calyx they are rounded on the back, but gradually increase as they flatten to twice the diameter at the lower end, and the plates to twice their length. Each alternate plate at

both sides of the arm is ornamented with a small spine, and these spines, which are placed along the sides of the arms, increase in length and thickness upward. Interbranchials three; the first very large and spinous, the two upper ones merely convex. Anal plate higher than the radials, and covered with a short central spine; the three succeeding plates are simply nodose, while the three or four small pieces above are scarcely convex. Ventral disk shorter than the dorsal cup, depressed hemispherical; the orals and radial dome plates spiniferous; the interambulacral plates nodose. Posterior oral very large and central; anal tube excentric and quite slender.

Column large, the plates short. The older joints are twice as wide as the intervening ones; the younger joints extremely short and flat at their sides. At 4 cm. from the calyx there are in one of our specimens seven joints to the internode, and these occupy only 4 mm. in length.

Horizon and Locality.—Lower part of the Upper Burlington limestone, Burlington, Iowa.

Type in the White collection in the University Museum at Ann Arbor.

Eretmocrinus corbulis (HALL).

Plate XXXVI. Figs. 5a, b, c, and 6.

1861. *Actinocrinus corbulis*—HALL; Prelim. Descr. of New Crinoids, p. 1, and Boston Journal of Nat. Hist., Vol. VII., p. 265.
 1873. *Batocrinus (Eretmocrinus) corbulis*—MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 368.
 1881. *Eretmocrinus corbulis*—W. and SP.; Revision Palæocr., Part II., p. 173.

Calyx subglobose, wider than high; the dorsal cup from one third to one half higher than the ventral disk, broadly truncate at the lower margin, the width at the base equal to one half the diameter at the arm bases, the sides gently spreading and slightly convex. Plates nodose; the nodes upon the radials and branchials transversely arranged, those upon the interbranchial plates subcircular; the surface smooth or obscurely granulated.

Base short, the upper margin deeply notched along the sutures; expanding outward and downward, projecting conspicuously beyond the top of the column, overhanging it, and forming a broad, shallow inverted basin. In some specimens the basals are so deeply notched that the lower angles of the radials, and that of the anal plate, constitute a part of the projecting rim, and sometimes even enter the lower concavity. Radials short, nearly twice as wide as long, their nodes directed downward. First costals not more than half the width of the radials, short, quadrangular, twice as wide as long, their

lower faces convex. Second costals pentangular, in width and length resembling the first. Distichals varying from two to three, owing to the number of arms in the specimen; smaller than the costals. When there are four arms to each ray, which probably is the normal number, they consist of 2×2 plates, and these are followed by 2×2 palmars; when, however, which is quite frequently the case, the anterior ray has only two arms, it has three successive distichals in both divisions. Specimens with three arms in the anterior ray are comparatively rare, in this case the one division has three distichals, the other two. Palmars short, in contact laterally, and rounded like arm plates, leaving longitudinal depressions at their sides. Arm facets large, directed outward; the ambulacral openings elongate, almost equidistant, the interspace between the two posterior rays being a little the widest. Respiratory pores large, separated from the ambulacral passages by thin partitions, which frequently are not preserved. Arms eighteen to twenty, stout, long, incurving and biserial. The lower portions of the plates are rounded, and every third plate of both series is extended to form a short lateral spine; the upper portions gradually grow flat, and increase in width to twice that at the bottom, but do not attain that sharp knife-like edge observed in some species of this genus. Interbranchials from one to three; the first very large rising to the top of the first distichals; the upper plates, when present, very minute. Anal piece higher than the radials; succeeded by three large plates, and these sometimes by one or two small ones. Ventral disk depressed hemispherical; the plates highly convex or nodose. Posterior oral strictly central, fully twice as large as any of the other plates, and surmounted by a high node. The four other orals and the radial dome plates are considerably larger and more prominent than the interambulacral pieces, some of which are quite small. Anal tube excentric and very slender; its length not known. Column near the calyx composed of high joints, angular along their edges.

Horizon and Locality.—Lower Burlington limestone, Burlington, Iowa, and Lake Valley, New Mexico.

Types in the Museum of Comparative Zoölogy, and in the University Museum at Ann Arbor.

Remarks.—This species was described by Hall as having twenty arms. Among twenty-one specimens in our collection, which all undoubtedly belong to it, there are ten with twenty arms; five have nineteen, and six but eighteen. The deficiency always occurs in the anterior ray.

Eretmocrinus leucosia (HALL).*Plate XXXVI. Figs. 7a, b, c.*

1861. *Actinocrinus leucosia* — HALL; Prelim. Desr. of New Crin., p. 1, and Boston Journ. of Nat. Hist., Vol. VII., p. 261.
 1877. *Batocrinus leucosia* — S. A. MILLER; Amer. Palæoz. Foss., p. 67.
 1881. *Eretmocrinus leucosia* — W. and SP.; Revision Palæocr., Part II., p. 173.
 1883. *Eretmocrinus leucosia* — S. A. MILLER; Amer. Palæoz. Foss. (Second Edit.), p. 282.
 Syn. *Dorycrinus confragosus* S. A. MILLER, 1891; Geol. Surv. Missouri, Bull. I., p. 34, Plate 5, Figs. 12 and 13.
 Syn. *Batocrinus Blairi* S. A. MILLER, 1892; Adv. Sheets 18th Rep. Geol. Surv. Indiana, p. 39, Plate 6, Figs. 7-10.

Of the type of *Eretmocrinus corbulis*, but a larger species. Calyx as high as wide, in large specimens somewhat wider; the rays slightly lobed at the arm regions, and grooved at the anal side. Dorsal cup broadly truncated at the base; the sides uniformly spreading from the top of the basals, forming a straight or very slightly concave line to the bases of the arms. Plates moderately convex, without ornamentation, the suture lines grooved and quite distinct.

Base short, projecting outward, and forming a salient, trilobate rim with sharp lower edges; the lower face perfectly flat except in the median part, which to one third the diameter at the bottom is slightly excavated; the axial canal large for this genus, and pentangular. Radials large, once and a half as wide as long, the upper face concave. First costals quadrangular, and small as compared with the radials; the second wider and pentangular, unless they are touched by the second row of interbrachials, which is exceptionally the case. Distichals two, short; followed in four of the rays by two exceedingly short, transverse palmars, which support the arms; in the anterior ray, which has no palmars, directly by the arms. Arm facets very large, directed slightly upwards, and arranged in groups. The interspaces between the rays considerably wider than those between their subdivisions, and somewhat grooved, especially at the anal side. Arms eighteen, massive, long, incurving, and biserial from the calyx up; they are given off in pairs, and the two arms of each pair are suturally connected to the height of the third arm plate. For quite a distance from the calyx, the arms are evenly rounded at the back, but they grow flatter toward the tips, and increase some little in width. The arm plates are moderately short, and every fifth piece in both series is provided with a lateral spine. The spines near the calyx are quite short, but those in the upper regions attain a length of 4 mm.

Interbrachials one and two, the first almost as large as the radials, the two upper ones either arched by the palmars, or followed by an additional elongate piece, which is interposed between the palmars and connects with the interambulacral plates. Anal plate narrower and higher than the radials, succeeded by three large, somewhat elongate plates, which support two or three smaller ones, and these another which rests between the arm bases. Ventral disk a little lower than the dorsal cup, irregularly hemispherical; plates convex, the orals and radial dome plates of the tegmen larger and more protuberant than the intervening plates, the posterior oral nearly central and twice as large as the four others. The radial dome plates are placed near the periphery, there being three large pieces over each ray, one above each arm pair, except in the anterior ray, in which there is but one piece. Anal tube large, subcentral, composed of nodose plates. Structure of arms not known.

Horizon and Locality.—Lower Burlington limestone; Burlington, Iowa, and Sedalia, Mo.

Type in the University Museum at Ann Arbor.

***Eretmocrinus rugosus* W. and Sp. (nov. spec.).**

Plate XXXVI. Figs. 9a, b, c.

A small, well marked species of the type of *Eretmocrinus leucosia*. Calyx wider than high, distinctly lobed at the arm regions. Dorsal cup depressed, broadly truncate at the base; the sides, which at their lower end spread but very little, expand abruptly from the top of the costals, and form a rim, which is almost at right angles to the base. Plates highly elevated; the radial ones formed into conspicuous rounded ridges, which extend to the entire width of the plates; the interrarial ones into rounded nodes. The surface of the ridges is covered by small, elongate prominences, forming longitudinal rows; the top of the interrarial nodes by similar excrescences which have a radiating tendency.

Basals extremely large, spreading outward and downward, and forming a broad rim, of which the suture lines are deeply indented at the sides and distinctly grooved at the lower face; the surface of the plates up to the column facet is covered by fine, rugose striæ. Radials short, more than twice as wide as long. Costals narrower and shorter than the radials; the first quadrangular, the second pentangular. Distichals 2×2 , smaller than the

costals; followed by 2×4 palmars, except in the anterior ray, which has three distichals and no palmars. Arm facets large, projecting, directed outward. Arm openings arranged in groups; the interspaces between the rays twice as wide as the others, and slightly depressed. Arms eighteen; their structure is not known, but they were evidently large. Interradials one or two, very small, and arched by the palmars. Anal plate shorter and narrower than the radials; it is followed by three and one plate of nearly equal size, and by a narrow elongate piece at the arm regions. Ventral disk about as high as the dorsal cup, hemispherical, slightly bulging along the sides, the principal plates sharply nodose. Posterior oral strictly central, more spinous and larger than the four others; the radial dome plates arranged in groups of three over each ray. Anal tube excentric and very small.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

Types in the collection of Wachsmuth and Springer.

Eretmocrinus coronatus (HALL).

Plate XXXVII. Figs. 7a, b, c.

1860. *Actinocrinus coronatus* — HALL; Suppl. Geol. Rep. Iowa, p. 28, Photogr. Plate 4, Figs. 1 and 2 (1872, N. Y. State Bull. I.).
 1873. *Eretmocrinus coronatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., Plate 10, Figs. 8a, b, c.
 1877. *Actinocrinus coronatus* — S. A. MILLER; Amer. Palæoz., Foss., p. 66.
 1881. *Eretmocrinus coronatus* — W. and SP.; Revision Palæocr., Part II., p. 173.
 1890. *Eretmocrinus coronatus* — S. A. MILLER; North Amer. Geol. and Palæont., p. 282.

A somewhat aberrant form, in its general habitus approaching *Dorycrinus*. Calyx about as high as wide. Dorsal cup a little shorter than the ventral disk, broadly truncate at the lower end, where its diameter is equal to one half the width at the top; a little lobed at the arm regions. The plates are highly convex or nodose, the suture lines distinct.

Basals stretched out horizontally, and sometimes hidden almost entirely by the overhanging nodes of the radials; they are deeply notched at the suture lines, forming a sort of trilobed plane, which in the central part is slightly excavated for the reception of a very small column. Radials moderately large, the two heptagonal ones with sharp salient angles, which fit in and rest within the lobes of the basal disk, and form a part of the lower surface. First costals quadrangular, twice as wide as long, narrower than the radials; the upper and lower faces straight. Second costals pentangular, generally a little longer than the first, and somewhat wider. Distichals two;

the upper one very short, leaf-like, and supporting the arms, except in the two posterior rays, in which the distichal next to the anal side is axillary, and supports on each side a single palmar, thus making the number of arms in these rays three, against two in the three others. Arm facets very large, directed obliquely upwards. Ambulacral openings elongate, arranged in groups, the interspaces between the rays twice as wide as those between their subdivisions, and at the posterior side almost three times as wide, and somewhat depressed. Structure of arms not known, but, to judge from the size of the facets, they were unusually stout, and were biserial from their origin. Interbrachials one, elongate, very large, arched by the arm-bearing brachials. Anal plate longer than the radials, the lower angle sharp and extending far down into the basal disk; it is followed by three large plates, and there is a smaller one between the palmars, which connects with the interambulacral pieces above. A similar small plate occurs exceptionally between the distichals at the other sides. Ventral disk depressed hemispherical. The orals are raised into short spines or sharp nodes; the posterior one central in position, a little larger, and less spinous. The radial dome plates, which are fully as large as the orals, and are also extended into spinous nodes, are placed around the periphery; there is one of these plates over the anterior and each antero-lateral ray, and three over the two posterior ones; the spines are directed slightly outward, and give to the tegmen that peculiar coronate aspect which is so characteristic of this species. Interambulacral plates small, and merely convex. Anal tube subcentral, very small at the base, its length not known.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the (Worthen) Illinois State collection.

Eretmocrinus intermedius W. and Sp.

Plate XXXIII. Figs. 2a, b, c.

1881. W. and Sp.; Revision Palæocr., Part II., p. 174.

A small species. Dorsal cup broadly truncate at the bottom, the sides straight or slightly convex. Plates almost flat; the radial ones marked by indistinct ridges, which pass into the arms; the interrarial plates covered with a small central node, and all obscurely fluted toward their margins.

Base short, broad, slightly projecting laterally, rounded along the margin, indistinctly grooved at the sutures, the lower surface excavated, and to one

half its diameter occupied by the column. Radials large, a little wider than long, the upper face concave. First costals narrower and shorter than the radials, twice as wide as long, upper and lower faces convex. Second costals generally a little longer than the first. Distichals 2×2 ; followed in the three anterior rays by two rows of two palmars, which support four arms; in the two posterior rays, in one or both divisions, at one side by one palmar and two post-palmars, at the other by two palmars, a structure which gives to these rays five to six arms, or twenty-two to twenty-four to the species. Arms stout, long, incurving, and biserial from the second free plate; they gradually increase in width, being at two thirds their length more than twice as wide as at the base, and perfectly flat. Also the plates increase upwards in length, and their outer faces become transversely angular. Interbranchials two; the first very large, the other quite small. Anal plate followed by three and two pieces. The upper row at all five sides is arched by the palmars and post-palmars. Structure of ventral disk not known.

Horizon and Locality.—Upper part of Keokuk group; Bono, Lawrence Co., Ind.

Types in the collection of Wachsmuth and Springer.

Eretmocrinus prægravis S. A. MILLER.

Plate XXXIV. Figs. 9, 10.

1892. S. A. MILLER; Adv. Sheets 18th Rep. Geol. Surv. Indiana, p. 37, Plate 6, Figs. 5 and 6.

A large, very knobby and robust species, in its ornamentation resembling *Lobocrinus Yandelli*; but the calyx more globular, less distinctly lobed, and with a different arm formula. Dorsal cup saucer-shaped, abruptly spreading from the base up, the plates heavy and covered with large angular knobs, some of which are arranged horizontally, others longitudinally.

Basals short, forming a hexagon with acute angles; the lower surface slightly excavated for the reception of the column, and pierced by a comparatively large axial canal. Radials twice as wide as long, covered with prominent transverse nodes, whose tips reach to the level of the lower margins of the basals. The node of the intervening anal is round, and the plate itself longer than the radials. First costals linear, less nodose than any of the other calyx plates, and sometimes completely flat. Second costals smaller than the first, depressed pentangular; their nodes subtriangular. The posterior and antero-lateral rays have but one distichal in their posterior

divisions, which is followed by 2×2 palmars and two arms; but in the anterior divisions by 2 successive distichals and a single arm. The anterior ray, which has but one arm in both divisions, has 2×2 distichals. Arm facets subcircular, concave, very large, and the surface covered with radiating striæ. Ambulacral openings quite small. Interbrachials: 1, 2, 1, 2 at the regular sides, and 3, 3, 2, 2 on the anal side; the upper row on a level with the arm bases. Ventral disk inflated, considerably higher than the dorsal cup, the conical upper end passing gradually into the anal tube. The plates of the tegmen decrease slightly in size toward the periphery, and are covered with sharp nodes as large as those of the dorsal cup. Orals excentric; the posterior one quite large. Anal tube stout and composed of large plates with sharp elongate nodes; it is almost central at the base, but curves a little to one side. Structure of arms and column unknown.

Horizon and Locality. — Keokuk group; White's creek Springs, near Nashville, Tenn., Pilot Knob, near Louisville, Ky.; Barren Co., Ky., and New Ross, Montgomery Co., Ind.

ALLOPROSALLOCRINUS Cass. and Lyon.

1860. CASSEDAY and LYON; Proceed. Amer. Acad. Arts and Sci., p. 29.
 1866. SHUMARD; Catal. Palæoz. Foss. North Amer., Part I., p. 353.
 1873. MEEK and WORTHEN (in part); Geol. Rep. Illinois, Vol. V., p. 368 (not M. and W., 1865, Proceed. Acad. Nat. Sci. Phila., p. 164).
 1879. ZITTEL; Handb. der Palæontologie, Vol. I., p. 370.
 1881. W. and SP.; Revision Palæocr., Part II., p. 113 (Proceed. Acad. Nat. Sci. Phila., p. 287).
 1890. S. A. MILLER; North Amer. Geol. and Palæont., p. 222.
 Syn. *Conocrinus* TROOST; List of Crin. of Tenn. (not defined).

Calyx conical, almost flat below the arm bases. Basals three, equal. Costals two, but generally so closely anchylosed that the line of union is invisible, and there is virtually but one plate. Distichals one or more, either followed by palmars, or directly supporting the arms. The arm-bearing plates in contact laterally, except upon the anal side, where they are separated by the second anal. Arms few to the ray, arranged in groups; their facets very large, subcircular and deeply notched at the upper end for the reception of the ambulacra. The interbrachials, so far as observed, consist of one large plate, except at the anal side, where the first anal is followed by a second, which at each side has two short interbrachial pieces. Ventral disk conical, its upper end gradually passing into the anal tube, which is stout and almost central. The ambulacra subtegmenal, their main trunks covered by superimposed interambulacral pieces, which are followed

by a large radial plate at each bifurcation. The orals pushed anteriorly. Respiratory pores arranged in ten pairs, five of them placed between the rays, the five others between their main divisions; they are well defined, and occupy the margin of the ventral disk, a little to one side of the ambulacral openings.

Distribution.—The only known species occurs in the Keokuk group of the Mississippi Valley.

Remarks.—The genus *Alloprosallocrinus* is most remarkable for the shortness of the dorsal cup contrasted with the great height of the ventral disk, in which it resembles *Agaricocrinus*. The form of the arm facets in the two genera is also quite similar, and they probably had the same kind of arms; but in *Agaricocrinus* the anus opens out laterally, directly through the disk, while in *Alloprosallocrinus* it is placed at the end of a tube, and besides, the former having two well defined costals.

Meek and Worthen's *Alloprosallocrinus euconus* is a *Dizygocrinus*; it resembles the former somewhat in its form, but it has two costals, the arms are comparatively thin, and become paired in mature specimens.

Casseday and Lyon's *Alloprosallocrinus depressus* is probably an *Agaricocrinus*; the type specimen is too much distorted to admit a correct diagnosis.

***Alloprosallocrinus conicus* CASS. and LYON.**

Plate XLII. Figs. 14a, b, c.

1860. CASSEDAY and LYON; *Proceed. Amer. Acad. of Arts and Sci.*, Vol. V., p. 29.

1866. SHUMARD (Subgenus of *Actinocrinus*); *Catal. Palæoz. Foss.* (Trans. Acad. Sci. St. Louis, Vol. II., p. 353).

1881. W. and SP.; *Revision Palæocr.*, Part II., p. 114 (*Proceed. Acad. Nat. Sci. Phila.*, p. 288).

Alloprosallocrinus Gurleyi S. A. MILLER; 1891, *Adv. Sheets 17th Rep. Geol. Surv. Indiana*, p. 58, Plate 10, Figs. 1 and 2.

Calyx pyramidal; the dorsal cup so flat that it is almost invisible from a side view; the ventral disk high and distinctly conical. Plates thick and devoid of ornamentation; those of the dorsal cup very slightly convex; the plates of the tegmen varying from convex to nodose.

Basals small, forming an inverted hexagonal basin. Radials wider than high, the lower portions bending inward, and forming a part of the basal concavity. Costals generally so closely anchylosed that a suture line cannot be traced, both together are pentangular, a little wider than the radials, and wider than long. Distichals 2×2 , except in the posterior rays, of which the divisions next to the anal interradius have but one, which is axillary and

supports 2×2 fixed palmars, and these the arms. The arm-bearing plates are once and a half as wide as those below or above, and in contact laterally. Their facets are irregularly crescent-shaped, and directed slightly upward; they do not occupy the middle of the plates, but lean to the inner sides of the rays, and leave large interspaces between adjoining rays. By means of this structure the arms are formed into groups as effectually as in other species by the interposition of interbrachial plates. The arms, which have not been observed in this species, were evidently quite ponderous to judge from the large size of their facets, and composed of two rows of short, leaf-like pieces, similar to those of *Agaricocrinus*. Interbrachials one; the plate large, higher than wide, and arched by the arm-bearing brachials. First anal plate followed by a very long second, which rises to above the level of the arm bases, and rests between two short interbrachial pieces. Ventral disk more than three times as high as the dorsal cup; the plates large and of about uniform size; the anal tube occupying the central part. The posterior oral is the largest plate of the tegmen, and, like the other orals, is pushed over to the anterior side. The ambulacra are subtegmenal, their upper portions being covered with superimposed interambulacral pieces, but on approaching the arms by large radial plates of a first and second order. The respiratory pores are large, and placed at some distance from the ambulacral openings.

Horizon and Locality.—Keokuk group; Pilot Knob, near Louisville, Ky.; White's creek, near Nashville, Tenn., and New Ross, Montgomery Co., Ind.

Remarks.—Miller's *Alloprosallocrinus Gurleyi* is a small example of *A. conicus*, in which one of the posterior rays has but two arms.

EUTROCHOCRINUS W. and Sr. (nov. gen.).

(Εὖ well, τροχός a wheel, κρίνον a lily).

Calyx large, wheel-shaped, narrow to the top of the radials, thence spreading abruptly until the sides of the dorsal cup are at right angles to the axis of the calyx. Ventral disk almost flat to near the base of the anal tube. Basal cup deep, subcylindrical, composed of three equal plates. Radials larger than both costals together; the first costal transversely linear, the second depressed pentangular. Distichals and palmars increasing in width upward. Ambulacral or arm openings equidistant or nearly so; directed sidewise. Arms single or in pairs, biserial, rounded, very short and

incurving; pinnules closely packed. Interbrachials variable in number, either arched over by the higher brachials, or in contact with the interambulacral pieces. Interdistichals frequently represented, and occasionally interpalmars. Anal tube stout, central and extremely long. Orals excentric; the posterior one much larger than the others and erect, forming the base of the anal tube at the anterior side. Column round, with a small pentangular canal.

Distribution.—Restricted to the Upper Burlington limestone and Keokuk group of America.

Type of the genus.—*Eutrochocrinus Christyi* (Shumard).

Remarks.—*Eutrochocrinus* approaches *Dizygocrinus* in its arm structure, but differs from it essentially in other respects. In *Dizygocrinus* the calyx is subglobose, the tegmen high, the arms rather long, the anal tube short and slender. In *Eutrochocrinus* the calyx is decidedly wheel-shaped, the ventral disk almost flat, the arms very short, and the anal tube extremely long.

Eutrochocrinus Christyi (SHUMARD).

Plate XXIX. Fig. 6, and Plate XXXII. Figs. 1a, b, c.

1848. *Actinocrinites* — CHRISTY's letters on Geology, Plate I., Figs. 1 and 2.
 1855. *Actinocrinus Christyi* — SHUMARD; Geol. Rep. Missouri by Swallow, Part II., p. 191, Plate A, Fig. 3.
 1873. *Batocrinus Christyi* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., Plate 5, Figs. 4a, b.
 1878. *Batocrinus Christyi* — W. and SP.; Proceed. Acad. Nat. Sci. Phila., p. 231.
 1885. *Actinocrinus Christyi* — QUENSTEDT; Handb. der Petrefactenkunde (Auflage 3), Plate 77, Fig. 4.
 1881. *Batocrinus Christyi* — W. and SP.; Revision Palæocr., Part II., p. 166.
 (not *Actinocrinus Christyi* — HALL, 1863 = *Periechocrinus Whitfieldi*).
 Syn. *Batocrinus bisbrachiatus* WHITFIELD; Mem. Amer. Mus. Nat. Hist., 1893, Vol. I., p. 13, Plate 2, Figs. 4, 5.
 Syn. *Batygerinus altiusculus* MILLER and GURLEY, 1894; Geol. Surv. Missouri, Bull. 3, p. 20, Plate 5, Figs. 1, 2, 3.

Calyx large, wheel-shaped; plates thick and without ornamentation.

Dorsal cup almost twice as high as the ventral disk; sides concave, gradually spreading to the top of the radials, and more abruptly thence to the arm bases; plates nearly flat.

Basal cup large, somewhat wider than high, a little thickened near the lower end, and projecting laterally beyond the sides of the column; the bottom deeply excavated. Radials quite variable in form, but generally longer than wide; the upper face concave. Costals small, both together not more than half the size of the radials; quadrangular and pentangular. Distichals and palmars in two rows; the latter larger than any of the other

brachials. The upper row of palmars deeply excavated for the reception of the free arms, and the facet occupied by a diminutive axillary, and two small arm plates, which support an arm each. There are twenty arm openings, arranged at nearly equal distances, and directed horizontally. Arms forty, two to each opening; they are short, infolding, comparatively thin, and composed from their bases up of two rows of short transverse pieces. Pinules flattened at their sides and contiguous. Interbrachials three to five in three rows, the lower one large, about as wide as high, the others small and arched over by the palmars, which meet laterally, forming a continuous ring. Anal plate elongate, followed by three, three and two plates. Ventral disk depressed near the periphery, the median portions gradually rising to support the anal tube. Plates convex; the orals and radial dome plates considerably larger than the interambulacral pieces. The orals placed anteriorly; the posterior one twice the size of the other four, directed upwards, and forming at the anterior side the base of the anal tube. Anal tube extremely long, sometimes arising to a height of four inches; thick at the base, but gradually tapering until it is quite slender at the upper end. Column of moderate size, round; the nodal joints rather high, cylindrical; the internodal ones increasing to four at three inches from the calyx.

Horizon and Locality. — A characteristic fossil of the Upper Burlington limestone; Burlington, Iowa, and several other places in Illinois and Missouri.

Remarks. — *Eutrochocrinus Cristyi* is very closely allied to *E. Lovei*, and unless the arms are preserved or the arm openings very perfect, it is difficult to separate them. That the two are evolved from a common type is well shown by the fact that in young specimens of *E. Christyi* one or two arms are frequently simple; while the larger ones invariably have two arms to each arm opening.

***Eutrochocrinus Christyi*, var. *trochiscus* (MEEK and WORTHEN).**

Plate XXXII. Fig. 3.

1868. *Batocrinus trochiscus* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 354.

1873. *Batocrinus trochiscus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 372, Plate 5, Fig. 6.

1878. Var. of *Batocr. Christyi* — W. and SP.; Proceed. Acad. Nat. Sci. Phila., p. 231, and 1881, Revision Palæocr., Part II., p. 163.

Larger, and throughout more extravagantly developed than the typical form. Calyx more spreading and comparatively shorter, narrower at the

base; the upper palmars abruptly curving upwards, and deeply excavated to form the arm facets. Ventral disk near its periphery flat or even concave, the plates nearest the margin highly tuberculous, projecting outward and upward. Anal tube stout, composed of heavy plates, which are surmounted by a short central spine. Interbrachials numerous, consisting of from six to eight pieces at the regular sides, and of about eleven to thirteen at the posterior one. There are frequently also from one to two interdistichals. Column composed of large, rather high joints with distinctly convex edges.

Horizon and Locality. — Burlington and Keokuk Transition bed, Des Moines Co., Iowa, and Nauvoo, Ills.

Type in the Museum of Comparative Zoölogy.

Remarks. — This variety forms a transition between *Eutrochocrinus Christyi* and *E. planodiscus*.

***Eutrochocrinus planodiscus* (HALL).**

Plate XXXII. Figs. 4a, b.

1860. *Actinocrinus planodiscus* — HALL; Suppl. Geol. Rep. Iowa, p. 45.

1873. *Batocrinus planodiscus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367.

1878. *Batocrinus planodiscus* — W. and SP., Proceed. Acad. Nat. Sci. Phil., pp. 231 and 233.

1881. *Batocrinus planodiscus* — W. and SP.; Revision Palæocr., Part II., p. 167.

Of the type of *E. Christyi*, but more closely approaching its variety *E. trochiscus*, with a greater expansion of the calyx than even in that form; conical in the lower portions. From the first costals to the third palmars the plates are arranged almost horizontally, the post-palmars decidedly curve upwards. Plates slightly convex, their surfaces smooth.

Basals as in *E. Christyi*. The radials comparatively smaller than in that species; the costals larger, especially the second. Distichals in two ranges, as large as, or larger than, the costals. Palmars three, supporting two rows of large post-palmars separated by interbrachials, interdistichals, and frequently by interpalmars. Arm openings forty, eight to each ray; supporting forty apparently delicate arms. According to Hall, the species has fifteen interbrachials in nine ranges, nine to eleven interdistichals, and five to six interpalmars. A specimen in our collection has only from six to seven interdistichals, four interpalmars, and about eighteen plates above the anal piece. Ventral disk depressed, deeply concave, except the median portions, which support the anal tube and are conical. The radial dome plates are more convex and larger than the interambulacral pieces. Posterior

oral projecting and three times as large as the four others, forming the base of the anal tube at its anterior side.

Horizon and Locality. — Keokuk group; Keokuk, Iowa, and Nauvoo, Ills.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — This species agrees fundamentally with *E. Christyi*, but has a much larger number of interbrachials, and numerous interdistichals and interpalmar, which are unrepresented in *E. Christyi*, and a much greater expansion of the rim. It also differs in having a large axillary palmar, and forty well defined arm openings around the calyx; while *E. Christyi* with the same number of arms has but twenty openings, a minute axillary, and two arms from each opening. Phylogenetically *E. planodiscus* is a more adult form of *E. Christyi*, but from a classificatory standpoint must be regarded as specifically distinct. The development of the rim from *E. Christyi* with its twenty arm openings and double arms, through *E. trochiscus* to *E. planodiscus*, with its forty independent arm openings, was coincident with the geological succession of the three forms.

Eutrochocrinus Lovei W. and Sp.

Plate XXIX. Fig. 7, and Plate XXXII. Figs. 2a, b.

1981. *Batocrinus Lovei* — W. and Sp., Revision Palæocr., Part II., pp. 47 and 168.

1890. *Batocrinus Lovei* — S. A. MILLER; North Amer. Geol. and Palæont., p. 228.

In its general habitus very closely resembling *Eutrochocrinus Christyi*, but a smaller species and differing essentially in the arm structure. Calyx wider than high, tapering abruptly to the poles, the sides convex. Plates without ornamentation, flat in the dorsal cup, convex on the ventral disk.

Basals forming a large conical cup, of which the lower face is occupied completely by the column. Radials larger than both costals together, about as long as wide, a little widest at the top. First costals small, quadrangular, twice as wide as long; the second somewhat higher; their sloping upper faces forming a right angle. Distichals and palmars in two rows of two plates each; the latter larger than the former, and the arm-bearing second palmars wider than any of the other brachials. Arm openings eighteen to twenty, narrow, directed slightly upwards, and arranged in groups of four—two in the anterior ray—with a shallow depression between the rays. Arms eighteen to twenty, single, short but somewhat larger than in *E. Christyi*; composed from their bases up of two rows of very short pieces.

Pinnules proportionally large. Interbrachials two to three; the first quite large, rising to the top of the first distichals. First anal plate narrower than the radials; followed by two rows of three plates, which are arched by the palmars. Ventral disk depressed convex, the interambulacral spaces slightly depressed; the orals and radial dome plates considerably larger and more convex than the intervening plates. Anal tube composed of almost flat pieces; central, rising considerably beyond the tips of the arms.

Horizon and Locality.—Lower portion of the Upper Burlington limestone; Burlington, Iowa.

Types in the collection of Wachsmuth and Springer.

DIZYGOCRINUS W. and SP. (nov. gen.).

(Δίζυγος two abreast, κρίνον a lily).

Calyx depressed-subglobose, biturbinate or subconical; the ventral disk generally as high as the dorsal cup, and sometimes considerably higher. Plates smooth, granular, or obscurely striated. Basals very short, forming a slightly projecting circular rim or shallow basin. Radials proportionally smaller than in *Batocrinus*; the first costals quadrangular, the second pentangular or rarely heptangular. The upper brachials either form a continuous ring around the calyx, or are separated (rarely) between the rays by a narrow interbrachial piece; the faces supporting the arms are excavated into subcircular or lunate facets, which are directed outward. Arms long and biserial, given off from the calyx either singly or in pairs. When the arms are paired, they start from a diminutive axillary, and the proximal arm plates and this axillary rest upon the same facet; when simple, a large cuneate plate takes the place of the three small pieces. Regular interradials from two to four, at the anal side five to eight. Anal tube almost central, slender, and rarely rising above the tips of the arms. Respiratory openings small.

Distribution.—This genus, so far as known, is restricted to the Subcarboniferous of America; it is represented in the Upper Burlington limestone by four species, reached its climax in the Keokuk group, and disappeared in the Warsaw limestone.

Type of the genus. — *Dizygocrinus indianensis* (Lyon and Casseday).

Remarks.—Most of the species for which we propose this genus were described originally by Hall under *Actinocrinus*, whence they were removed by Meek and Worthen, and placed under *Batocrinus*. *Dizygocrinus eucomus*

was described by Meek and Worthen as an *Alloprosallocrinus*, and *D. originarius* and *D. adultus*, which have slightly spatulate arms, by us under *Eretmocrinus*.

The most noteworthy feature of *Dizygocrinus* is presented by the structure of the arms in their tendency to multiplication, a peculiarity in which it differs from all other known genera except *Eutrochocrinus* and *Dorycrinus*.

It has been supposed that the number of arms, and their distribution among the rays, afforded excellent characters for specific separation, a rule which certainly does not apply to this genus. Among the species which we refer to it, some specimens have twice as many arms as others, and we find any intermediate number between the two extremes. If it were true that all these variations were of specific importance, the number of species in this genus would have to be increased to the number of permutations and combinations that would be mathematically possible out of the fourteen single and double numbers into which these arms may be arranged. In *Dizygocrinus mutabilis* every specimen in our collection — seven in all — would constitute a different species, as shown by the following formulæ:

$$\begin{array}{cccc}
 \begin{array}{c} 1, 2, 1, | 2, 1, 1, \\ 1, 1, 2, | 2, 1, 1, \\ \hline 2, 1. \end{array} & \begin{array}{c} 2, 2, 2, | 2, 2, 2, \\ 2, 2, 2, | 2, 2, 2, \\ \hline 2, 2. \end{array} & \begin{array}{c} 2, 1, 1, | 1, 1, 2, \\ 2, 2, 1, | 2, 1, 2, \\ \hline 2, 2. \end{array} & \begin{array}{c} 2, 1, 1, | 1, 1, 2, \\ 2, 1, 2, | 1, 1, 2, \\ \hline 1, 2. \end{array} \\
 \begin{array}{c} 2, 1, 1, | 1, 1, 2, \\ 1, 1, 2, | 2, 2, \\ \hline 2, 2. \end{array} & \begin{array}{c} 2, 2, 1, | 1, 2, 1, \\ 2, 1, 2, | 2, 2, \\ \hline 2, 1. \end{array} & \begin{array}{c} 1, 2, 2, | 2, 1, 2, \\ 1, 1, 1, | 2, 2, \\ \hline 2, 1. \end{array} &
 \end{array}$$

A careful study of these specimens shows that they all must belong to the same species. They have fourteen arm openings (exceptionally thirteen), and an equal number of arm facets; but while some of them have paired arms, others have single ones. In some species of this genus, the arms are more frequently either all single or all paired, but among them also transition forms occur; sometimes one or two arms only being single or double, and again one half of them. As a rule, the specimens with single arms are smaller, the arms stouter; but in other respects they resemble those with paired arms so closely, that they cannot be recognized from the calyx alone. This has induced us in some cases to refer both forms to the same species, but to distinguish them by an appropriate variety name.

Dizygocrinus indianensis (LYON and CASS.).*Plate XXXIII. Figs. 6a, b, and Plate XXXV., Fig. 5.*

1860. *Actinocrinus indianensis*—LYON and CASS.; Amer. Journ. Sci., Vol. XXIX., p. 75.
 1873. *Actinocrinus indianensis*—MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 341.
 1881. *Batocrinus indianensis*—W. and SP.; Revision Palæocr., Part II., p. 166.
 1884. *Batocrinus indianensis*—QUENSTEDT; Handb. der Petrefactenkunde, Plate 77, Figs. 6a, b.

Calyx below medium size, biturbinate to subglobose, about as wide as high; the dorsal cup a little higher than the ventral disk. The sides of the cup slightly convex, expanding almost uniformly from the base to the arm regions; the rays well defined by undulated angular ridges following the median portions of the plates. In addition to these ridges, the surface of all radial as well as interrarial plates is covered by a variety of prominences and depressions, which give to the ornamentation a hieroglyphic appearance.

Basals short, slightly projecting, hexagonal in outline; interbasal suture lines impressed. Radials twice as wide as long, covered with three stellate prominences, which, being confluent, form a transverse ridge. First costals quadrangular, shorter and narrower than the radials, the sides convex, the median ridge crossed either by a transverse node, or by a row of small tubercles transversely arranged. Second costals generally heptagonal and a little wider than the first, their median portions raised into small tubercles. Distichals rather large, nearly as long as wide; they consist in the anterior ray of 4×2 plates, in the four others of 2×2 , which are followed by 3×2 fixed palmars. Arms thirty-six (exceptionally forty), two from each arm opening; long, slightly flattened and infolding at their tips; they are biserial from their bases up, and the plates connected vertically by waving sutures. The upper border of each arm plate is covered by two or more small tubercles, which project over the lower end of the succeeding plate, giving to the surface a file-like appearance. Pinnules long, cylindrical, composed of about thirteen elongate joints. Interbranchials: 1, 2, 1, and one or two additional pieces between the arm bases. The first plate is considerably larger than the others, wider than high; it is covered by a central, irregularly stellate node, surrounded by numerous small granules; the upper plates elongate and similarly ornamented. Anal plate a little narrower than the radials; followed by 3, 3, 2, and 2 pieces, which interlock with the interambulacral plates above. Ventral disk depressed conical; the plates small

and tuberculous; the orals and radial dome plates a little more prominent, but not much larger than the others. Anal tube almost central, comparatively narrow, and rising but little above the tips of the arms. Column rather stout, the joints rounded at their edges; the nodal joints quite prominent.

Horizon and Locality.—Keokuk group; Crawfordsville, Ind.

Types in the Lyon collection at Jeffersonville, Ind.

Remarks.—Specimens in which single arms are placed between the paired ones are very rare in this species. Among over forty specimens in our collection we found but two. One of them has seventeen paired arms and one single one, the other twelve single and six paired ones. The latter specimen is so interesting that it deserves special description, and we give an illustration of its posterior side (Plate XXXV., Fig. 5). What is most remarkable is that the arms differ greatly in width and length; seven of the single ones are twice as strong as the three others, and one fourth longer; the latter three having the same dimensions as the paired ones. The arrangement is shown by the following formula:

Posterior rays: 1 large, 2, 2, 2;—1 small, 1 large, 1 small, 2.

Antero-lateral rays: 1 small, 1 large, 1 large, 1 large;—1 small, 2, 1 small, 2.

Anterior ray: 1 large, 1 large.

It is possible that this specimen originally had single arms, and that some of them were accidentally broken and replaced by paired ones.

Dizygocrinus indianensis, var. **simplex** W. and Sp. (nov. var.).

Plate XXXIII. Fig. 7.

Somewhat smaller than the typical form. In the proportions of the calyx, the ornamentation, and in the arrangement of the plates to the top of the distichals, the two forms are almost identical; but in the form under consideration only two rows of the palmars are incorporated into the calyx, against three in the typical form; the third is a free arm plate; the fourth, in place of being a diminutive axillary, is large and cuneate, and supports but one arm. There are eighteen single arms, distributed among the rays in exactly the same way as the double arms in the other. The arms have the same file-like appearance, but are proportionally a little stouter.

Horizon and Locality.—Same as last. Extremely rare; we have only seen a single specimen, which is in our collection.

Dizygocrinus crawfordsvillensis* S. A. MILLER.

1891. *Batocrinus crawfordsvillensis*, S. A. MILLER; Adv. Sheets 17th Rep. Geol. Surv. Indiana, p. 64, Plate 10, Fig. 11.

A rather small species. Dorsal cup obconical, truncated at the base, nearly one half wider than high, the sides almost straight; the radials and brachials marked by well defined angular ridges, following the median line of the plates and proceeding to the arm bases; the interbrachials convex, covered with obscure radiating ridges.

Basals short, extended outward and forming a small rim; columnar concavity deep, occupying one half the diameter of the lower face. Radials considerably wider than long. First costals quadrangular, the length equal to one half their width; the second pentangular, of nearly the same proportions as the first. Distichals two in the antero-lateral rays, followed by five palmars, which support the arms. The anterior ray has five distichals and no palmars; while in the posterior rays the division adjoining the anal side has two distichals and five palmars, and the opposite division five distichals, making sixteen arm openings with two arms from each opening, or thirty-two to the species (not twenty-four, as stated by Miller). The arms are incurving, very delicate, and so short that when recurved they reach but little above the summit of the disk. Regular interbrachials three, the first large, the others quite small. The anal interradius consists of six plates including the anal; three in the first row, and two in the second. Ventral disk convex, as high as the dorsal cup, the plates large and tumid. Anal tube nearly central.

Horizon and Locality. — Keokuk limestone; near Crawfordsville, Montgomery Co., Ind.

Type in the collection of Professor Gorby.

Remarks. — This species resembles *Dizygocrinus indianensis*, from which it differs in the number of brachials, and in the more delicate and much shorter arms.

* We give no figure of this species, as we were unable to obtain the type, and our description is made after Miller's.

Dizygocrinus facetus (MILLER and GURLEY).*Plate XXXIII. Fig. 12.*1890. *Batocrinus facetus* — MILLER and GURLEY; Journ. Cincin. Soc. Nat. Hist., Vol. XIII. (Authors' copy, p. 35), Plate 6, Fig. 8.

Calyx below medium size, wider than high; in ornamentation and general appearance resembling *D. indianensis*, but having less than half the number of arms. Dorsal cup semiglobose; the radial plates marked by narrow ridges, which follow the median portions of the plates. Plates convex, covered with irregular striæ and small nodes. Suture lines grooved and rather distinct.

Base very short, circular, almost resembling a stem joint. Radials short, nearly twice as wide as long; the upper face concave. First costals comparatively large, quadrangular, as long as the radials but considerably narrower; their upper and lower faces convex. Second costals a little wider but not longer than the first; heptagonal; the upper faces obtusely angular. Distichals varying in number; the anterior ray having three rows, which support the arms; the antero-lateral ones but two, followed by two fixed palmars. In the two posterior rays, the axillary costal supports upon the side facing the anal interradius two rows of distichals followed by 2×2 palmars, upon the opposite side three distichals. Arm formula: $\frac{3}{2}\frac{3}{2}$. Arm bases projecting, directed obliquely upward, and separated interradially by small interbrachial pieces, which connect with the plates of the ventral disk. Arms single, long, decidedly tapering until quite slender at the tips; composed from the third joint up of two series of rather long joints. Pinules extremely long, stout, cylindrical, formed of ten to twelve joints, which are about four times as long as wide. Interradials: 1, 2, 1, and one or two irregular pieces in the arm regions. Anal plate as large as the radials, supporting 3, 3, 2, and 1 plate. Ventral disk depressed conical, the plates tumid and of regular size; anal tube slender but comparatively long, composed of nearly flat pieces, among which at intervals others are interposed bearing sharp tubercles. Column round; the nodal joints with rounded, strongly projecting edges.

Horizon and Locality. — Keokuk group; Canton, Ind.

Remarks. — This species was described as having seventeen arms, which is abnormal, the regular number being sixteen. Neither has it "eleven anal plates." The authors evidently mistook the lateral ends of the arm-bearing

brachials, which are covered with small tubercles, for distinct plates. Whether any multiplication of arms took place in this species is not known.

Dizygocrinus Whitei W. and SP.

Plate XXXIII. Figs. 10a, b, and Fig. 11.

1881. *Batocrinus Whitei* — W. and SP.; Revision Palæocr., Part II., p. 169.
 Syn. *Batocrinus spergenensis* S. A. MILLER, 1891, Adv. Sheets, 17th Rep. Geol. Surv. Indiana, p. 60,
 Plate 10, Figs. 5 and 6.

Calyx small, depressed globose; the dorsal cup equal to, or but little higher than, the ventral disk; the arm regions slightly projecting. Surface of plates ornamented. The radials and brachials have along their median lines a well defined ridge, and at each side of this ridge, toward the sides of the plates, an angular node, which appears in the specimens as if forming an independent plate. Ridges or rows of small tubercles occur also on the interbrachials, some of them proceeding from the centre of the first plate to the radials, others to the higher interbrachials.

Basals short, forming a projecting circular rim, with a shallow striated depression for the reception of the column. Radials twice as wide as long; the sloping upper sides shorter than the corresponding lower ones. Costals considerably shorter and narrower than the radials; the first quadrangular, the second pentangular. Distichals 2×2 , of similar form, but smaller than the costals; in the anterior ray supporting the arms; in the other rays followed by two rows of palmars. The upper faces of all arm-bearing plates are directed outward, and formed into circular, rather large facets with a notch at the upper end. The surface of these facets is slightly concave, and grooved at the inner margin. Arms eighteen, single, infolding, gradually tapering, and constructed from the second free plate of two series of moderately long pieces. Pinnules very long, composed of joints three times longer than wide. Interbrachials: 1, 2, 1, sometimes with an additional narrow piece between the arms. Anal plate somewhat higher than the radials, and followed variously by 3, 3, and 2 plates or by 3, 2, and 1; the latter being generally the case in specimens from the Keokuk group, the former in those from the Warsaw limestone. Plates of the ventral disk of nearly equal size, all covered with a sharp central tubercle. Anal tube long, extended beyond the tips of the arms, constructed of convex plates interspersed with slightly nodose or spinous pieces. Column slender; composed of large and smaller joints, the larger ones with convex edges.

Horizon and Locality.—In the Keokuk group at Bono, Indiana, and at Keokuk, Iowa. Also in the Warsaw limestone at Spergen Hill, Ind., and at Glasgow, Barren Co., Ky., and Boonville, Mo.

Types in the collection of Wachsmuth and Springer.

Remarks.—Miller's *Balocrinus spergenensis* was described from a specimen of *Dizygocrinus Whitei* in which the surface markings were eliminated by weathering. Specimens of this kind occur frequently at Spergen Hill, while well preserved specimens are rare.

***Dizygocrinus Whitei*, var. *didactylus* W. and Sp.**

Plate XXXV. Figs. 12, 13.

About the same size as the typical form, but the arms considerably thinner, and there are two arms to each opening when perfectly developed, which, however, is rarely the case. The radials and fixed brachials are traversed longitudinally by a strong, angular ridge. The arms are given off from a minute axillary in the usual way, and are slender, long, and infolding.

Horizon and Locality.—Uppermost part of the Keokuk group; Hamilton, Ills.

Types in the collection of Wachsmuth and Springer.

***Dizygocrinus decoris* (S. A. MILLER).**

Plate XXXV. Fig. 6.

1891. *Balocrinus decoris*—S. A. MILLER; Adv. Sheets 17th Rep. Geol. Surv. Indiana, p. 61, Plate 10, Figs. 7 and 8.

Calyx of medium size, a little wider than high. Dorsal cup low saucer-shaped, less than half the height of the ventral disk. Plates of the dorsal cup barely convex, their surfaces covered with numerous minute irregular pustules, and the radials and costals marked by small angular ridges, which from the basals pass up to the arm bases. The sutures very slightly grooved.

Basals quite short, anchylosed, and no suture lines visible; they merely consist of a thickened circular rim, which projects slightly over the top of the column. Radials and costals very short, both fully three times as wide as long. The costals support 2×2 distichals, and these three rows of palmars, of which the upper supports the arms, except sometimes in the anterior ray, which occasionally only has two arms given off from four successive distichals. All distichals and palmars are comparatively wide and very short, the latter in contact laterally. Arm facets nearly equidistant, large,

subcircular with a small notch at the upper end, and provided with a transverse, imperforate ridge. Arms single, so far as can be ascertained from the facets; their structure not known. Regular interbrachials: 1, 2, 2; the first large and considerably wider than high; the upper range, which sometimes consists of but one plate, arched by the palmars. Anal plate short, followed by seven or eight plates. Ventral disk conical, surmounted by a large, nearly central anal tube. Plates of the disk comparatively large and tumid; the orals somewhat larger and in contact; the posterior one erect, and forming a part of the tube. Ambulacral plates represented by three sharply nodose plates of a first and second order.

Horizon and Locality. — Warsaw limestone; Spergen Hill, Ind., and Barren Co., Ky.

Remarks. — This species has its closest affinities with *D. Whitei* W. and Sp., but the cup is less deep, and the tegmen in proportion much higher.

***Dizygocrinus originarius* W. and Sp.**

Plate XXXIII. Figs. 1a, b.

1881. *Eretmocrinus originarius* — W. and Sp.; Revision Palæocr., Part II., p. 174.

Syn. *Eretmocrinus varsoviensis* — WORTHEN; 1882, Geol. Rep. Illinois, Vol. VII., p. 306, Plate 28, Fig. 14.

A small species of the type of *Dizygocrinus Whitei*. Calyx biturbinate, as high as wide; the dorsal cup a little higher than the ventral disk, with almost straight sides and broadly truncated base; arm regions projecting, and somewhat indented at the interradian spaces. Plates slightly convex, covered with obscure granules, and the radials and brachials marked by a faint longitudinal ridge, which bifurcates and sends branches to the arms.

Basals a little larger than in any of the preceding species; forming a short, broadly truncated cup, with a shallow columnar depression, the sides somewhat projecting and slightly grooved at the sutures. Radials as large as both costals together, wider than long. First costals quadrangular, twice as wide as long; the second a little wider and pentangular. Distichals two or three; the anterior ray has three, followed by arm plates; the antero-lateral rays two, followed by two rows of small palmars; the posterior rays have two at one side, followed by 2×2 palmars, and at the opposite one three successive distichals. Arms sixteen, simple, stout in proportion to the small size of the species, rather short, and somewhat flattened at the tips; they are composed from the second plate up of two series of pieces, which

grow more convex upward. Interbrachials two; the first almost as large as the radials; the second much smaller and arched over by the two upper brachials. Anal plate considerably longer than the radials; followed by 3, 2, and 1 plate; the latter generally in contact with the interambulacral pieces. Ventral disk a little shorter than the dorsal cup, hemispherical, surmounted by a short slender anal tube; the plates convex. Column stout, the older joints rounded at their edges and projecting.

Horizon and Locality. — Upper part of the Keokuk group at Bono and Canton, Ind.; also in the Lower part of the Warsaw limestone at Boonville, Mo.

Types in the collection of Wachsmuth and Springer.

Dizygocrinus Gurleyi (S. A. MILLER).

Plate XXXIV. Fig. 19.

1891. *Batocrinus Gurleyi* — MILLER; Adv. Sheets Geol. Surv. Ind. (17th Rep.), p. 66, Plate 11, Figs. 9 and 10.

(Not *Batocrinus Gurleyi* ROWLEY and HARE, Aug. 1891).

Of the type of *Dizygocrinus originarius* W. and Sp., and so closely resembling it that there is much doubt if it is a good species. The specimens from Bono, described by us as "*Eretmocrinus*" *originarius*, only differ from the Boonville ones, which Miller has referred to *Batocrinus Gurleyi*, in having at the regular sides three interbrachials in place of two, and six pieces in place of five above the anal plate. The arms are a little longer and more slender at their tips, the angular ridges along the rays somewhat higher, and the surface markings upon the plates a little more distinct. The sides of the dorsal cup in one of Miller's types are concave, in the other convex; while they are nearly straight in the Bono specimens. We give a figure of one of Miller's types for comparison.

Horizon and Locality. — Lower part of Warsaw limestone, Boonville, Mo.

Type in the collection of F. A. Sampson, Esq.

Dizygocrinus originarius, var. **adultus** (W. and Sp.).

Plate XXXV. Figs. 14 and 15.

1881. *Eretmocrinus adultus* — W. and Sp.; Revision Palæocr., Part II., p. 175.

Syn. *Batocrinus mediocris* — S. A. MILLER; Adv. Sheets 17th Rep. Geol. Surv. Ind., p. 62, Plate 10, Fig. 9.

Syn. *Batocrinus boonvillensis* S. A. MILLER; *ibid.*, p. 65, Plate 10, Fig. 13.

In the form of the calyx, arrangement of the plates, number of arm openings, and the ornamentation, almost identical with the preceding form; the specimens, however, are larger, the arms paired and somewhat more slender. The two arms are given off from a diminutive axillary, which occupies the same facet with the proximal arm plates. Occasionally one or more of the arms are single, and in a very interesting specimen of *D. originarius* (typical form), which had evidently lost two of its single arms during life, these were replaced by two pairs, which are developed to only one half the length of the others.

Horizon and Locality.—Upper part of Keokuk group at Bono, Lawrence Co., Ind., and in the lower part of the Warsaw limestone at Boonville, Mo.

Types in the collection of Wachsmuth and Springer.

Remarks.—In the specimens which Miller described under *Batocrinus boonvillensis* and *B. medioeris*, the double arm structure is only partly developed; some of the arms being single, others paired. The modifications thereby produced in the arm formula probably led Miller to regard them as specifically distinct.

***Dizygocrinus cantonensis* W. and Sp. (nov. spec.).**

Plate XXXIII. Figs. 8a, b.

Calyx depressed; the dorsal cup very short, rapidly and uniformly spreading to the bases of the free arms; its sides straight or slightly convex, the plates flat and apparently without ornamentation.

Basals short and narrow, forming a circular ridge around the column. Radials comparatively small, once and a half as wide as long. First costals a little narrower than the radials, twice as wide as long, quadrangular, their lateral faces convex. Second costals pentangular, somewhat wider and longer than the first. That of the anterior ray supports two rows of two distichals, which are as large as the radials and support the arms. The costals of the four other rays have at one side an axillary distichal, followed by 2×2 palmars, at the other two large distichals, thus making the arm formula 3, 3, 2. The arm-bearing plates support at their upper facet a small trigonal axillary, and at each side of it an arm plate. Arms far apart, paired, rather long, incurving, rounded in the lower portions, but distinctly flattened and almost twice as wide in the upper. Pinnules rather stout and long. Interbranchials four to five, joining the interambulacral pieces; the anal

interradius consists of 1, 3, 2, and 2 plates. The ventral disk is hidden by the arms in all our specimens. Anal tube composed of flat pieces; it is rather stout and long, reaching to nearly an inch beyond the tips of the arms, and evidently was still longer. Column small, composed of thicker and thinner joints with rounded edges.

Horizon and Locality. — Keokuk group; Canton and Edwardsville, Ind.

Types in the collection of Wachsmuth and Springer.

Remarks. — This species has its closest affinities with the preceding form, but is readily distinguished by its larger size, the more abrupt spreading of the dorsal cup, the greater length of the anal tube, its spatulate arms, and by having fourteen pairs of arms instead of sixteen.

***Dizygocrinus unionensis* (WORTHEN).**

Plate XXXV. Figs. 16, 17, 18, 19, 20.

1884. *Batocrinus unionensis* — WORTHEN; Bull. II. of Illinois State Museum, p. 26.

1890. *Batocrinus unionensis* — WORTHEN; Geol. Rep. Illinois, Vol. VIII., p. 84, Plate 12, Figs. 5, 5a, and Plate 13, Fig. 3.

Syn. *Batocrinus pulchellus* — S. A. MILLER; 1891, Adv. Sheets 17th Geol. Rep. Indiana, p. 68, Plate 11, Figs. 13 and 14.

Syn. *Batocrinus Davisi* — ROWLEY and HARE; 1891, Kansas City Scientist, p. 116, Plate 3, Fig. 9.

Syn. (?) *Actinocrinus Caroli* — HALL; 1860, Suppl. Geol. Rep. Iowa, p. 54.

Of moderate size. Calyx depressed; the dorsal cup shorter than the ventral disk, almost saucer-shaped; the upper brachials placed nearly at right angles to the axis of the calyx. Plates slightly convex, covered with obscure granules, the median portions of the radials and costals marked by small transversely arranged nodes, which are confluent and form ridges. Suture lines more or less grooved.

Basals short, annular, slightly projecting beyond the column. Radials twice or three times as wide as long, their upper faces concave. Costals as long as the radials but narrower; the first quadrangular, the second pentagonal or heptangular. Distichals 2×2 , followed by two rows of palmars, except in the anterior ray which has three successive distichals. Palmars and distichals of similar form, and as large as the costals. Arms single, generally eighteen, arranged at equal distances around the calyx; of moderate length, rounded on the back, and biserial from the second free plate. The two proximal arm plates quadrangular, somewhat wedge-shaped, and as large as the first palmars. Pinnules stout; their joints

twice as long as wide. Interbrachials two or three on the regular sides, three to six on the posterior; arched by the palmars. Anal plate a little higher than the radials, occasionally followed by two plates in the second range in place of three; the second anal, although present, not in contact with the first. Ventral disk highly convex, slightly conical, the plates nodose and of irregular arrangement. Anal tube slender, almost central. Column thin; composed of larger and smaller joints.

Horizon and Locality. — Warsaw limestone, near Huntsville, Ala., Tateville, Pulaski Co., Ky., Boonville, Mo., and Lee Co., Va.

The *type* specimen, which is from Union Co., Ills., is in the (Worthen) Illinois State collection.

Remarks. — This species is very interesting as having sometimes in the posterior interradius but two plates above the anal piece, in which it shows a tendency toward the Actinocrinidæ. It also has a wide geographical range, and may be regarded as one of the leading forms of the lower part of the Warsaw limestone, but occurs already in the Upper Keokuk beds.

Actinocrinus Caroli Hall is very possibly identical with this species, but the type in the Illinois State collection at Springfield is too imperfect for accurate definition.

***Dizygocrinus unionensis*, var. *divalis* (S. A. MILLER).**

Plate XXXV. Figs. 21, 22, 23, 24.

1892. *Batocrinus divalis* — S. A. MILLER; Adv. Sheets 18th Rep. Geol. Surv. Missouri, p. 22, Plate III., Figs. 6 and 7.

A little larger than the typical form; the dorsal cup more expanded, the ventral disk somewhat more conical, but so closely resembling it in its general habitus, in the form and arrangement of the plates and their ornamentation, that the two cannot be distinguished unless the arms are preserved. Arms double from their origin, thirty-six in fully developed specimens, rather stout and densely crowded. Arm joints of more than medium length. At the four regular sides, the interbrachials consist of three to four pieces, at the anal side of from six to eight.

Horizon and Locality. — Associated with the preceding form at Boonville, Mo., and at Huntsville, Ala.

Types in the collection of Mr. S. A. Miller.

Remarks. — That we have here a mere variety of *Dizygocrinus unionensis*,

and not a distinct species, is clearly shown by the fact that one of our specimens has but a single paired arm; in another all the arms are paired except one, and that we find all variations between these extremes.

(?) *Dizygocrinus Gorbyi* S. A. MILLER.

1891. *Batocrinus Gorbyi*—S. A. MILLER; Ad. Sheets 17th Rep. Geol. Surv. Indiana, p. 63, Plate 10, Fig. 10.

Of medium size. Calyx globose, height and width as eight to eleven; the arm bases projecting, the ambulacral openings directed upwards. Surface of plates convex, the radials and brachials transversely angular; the suture lines beveled.

Basals forming a hexagonal disk, two thirds wider than the diameter of the column, the plates upright, exposing a height about equal to the distance from the column to the upper margin. Radials very little longer than wide, the upper face slightly arcuate. First costals quadrangular, about one fourth wider than long; the second wider and longer than the first, two of them pentangular, the others hexangular. Distichals 2×10 , generally wider than long, the upper ones larger; nine of them bear a palmar; the one of the anterior ray supporting directly an arm. Arms nineteen, simple, long, rounded on the back. Pinnules composed of ten to twelve long joints. Regular interbrachials three; the first large, nine-sided; the two upper smaller. Anal side composed of nine plates; the anal plate the largest of the cup; followed by 3, 3, and 2 plates, which decrease in size upward. Ventral disk conoidal, covered with convex plates. Anal tube almost central, small, cylindrical; composed of rather large, slightly convex plates. Column round, of medium size.

Horizon and Locality.—Lower part of the Warsaw limestone; Boonville, Mo.

Type in the collection of Prof. S. S. Gorby at Indianapolis.

Remarks.—This species needs to be compared with the type, as Miller's description, from which we give an extract above, does not agree with his figure. This is especially the case with regard to the proportions of the basals, radials, and costals. The "upright" basals are not seen at all in the figure; the radials, and costals, which were said to be but very little wider than long, appear extremely short, the distichals are unusually large, and are followed by two palmars in the calyx, not by one as described.

Dizygocrinus biturbinatus (HALL).*Plate XXXIII. Fig. 9.*

1858. *Actinocrinus biturbinatus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 616, Plate 16, Figs. 5 and 6a, b, c.
 1873. *Batocrinus biturbinatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367.
 1881. *Batocrinus biturbinatus* — W. and SP.; Revision Palæocr., Part II., p. 165.
 Syn. *Batocrinus lyonanus* MILLER and GURLEY, 1894; Geol. Surv. Illinois, Bull. 3, p. 18, Plate 3, Figs. 4 and 5.

Calyx biturbinate, about as wide as high, the ventral disk as high as the dorsal cup. Plates below the arm regions flat, above slightly convex, their surface perfectly smooth; suture lines indistinct.

Basals small, forming a hexangular, shallow basin, with a slightly projecting rim at their lower margins. Radials once and a half as wide as long, the upper face straight. First costals quadrangular, considerably narrower and shorter than the radials; the second a little longer than the first and pentangular, their sloping upper faces at right angles. Distichals three in the anterior ray, two only in the antero-lateral ones. In the posterior rays, the divisions next to the anal interradius have two distichals, the others three. All divisions with two distichals are followed by 2×2 palmars, those having three directly by free arm plates. Arms sixteen (exceptionally seventeen, there being sometimes an additional one in the anterior ray); simple, slender, pointed at their ends, and incurving; they are biserial from the second free plate, and provided with slender, long-jointed pinnules. Inter-radial spaces slightly depressed at the arm regions. Regular interbranchials three to four; the first very large, as wide as high. The anal interradius contains from seven to nine pieces, the anal plate being succeeded by three plates, and these by three and two; occasionally there is another small plate above, separating the palmars, and a similar plate sometimes occurs at the other sides. Ventral disk subconical, and extended into a central anal tube. The plates are but slightly convex and of almost uniform size, except that the posterior oral is twice as large as any of the four others. Column decidedly tapering; the joints nearest the calyx nearly twice as wide as those two inches farther down, the former with convex edges, the others almost cylindrical, and there are six joints to the last internode that is preserved in the specimen.

Horizon and Locality. — Keokuk group, near Keokuk, Iowa.

Types in the (Worthen) Illinois State collection, Springfield.

Remarks.—Professor Hall described this species as having but two plates above the anal piece, which is certainly abnormal, as our specimens clearly show the presence of three plates.

***Dizygocrinus montgomeryensis* WORTHEN.**

Plate XXXIII. Figs. 3, and 4, and Plate XLVI. Fig. 10.

1894. *Batocrinus montgomeryensis* — WORTHEN; Bull. 2, Illinois State Mus. Nat. Hist., p. 25, and Geol. Rep. Illinois, Vol. VIII., p. 83, Plate 12, Figs. 2, 2a.
 Syn. *Batocrinus Gurleyi* — ROWLEY and HARE (not S. A. Miller), 1891, Kansas City Scient., Vol. V., p. 115, Plate 3, Fig. 7.
 Syn. *Batocrinus Sweeti* — ROWLEY and HARE, 1891, *ibid.*, p. 116, Plate 3, Fig. 8.

Calyx of medium size. Dorsal cup saucer-shaped, lower than the ventral disk, rounded at the sides; the arm-bearing plates produced outward in form of tooth-like projections around the calyx. Plates from perfectly flat to slightly elevated, and without ornamentation.

Basals small and short, forming a basin-shaped depression, which is completely filled by the upper stem joint. Radials twice as wide as long, the upper face concave. First costals a little shorter and considerably narrower than the radials; the second slightly longer and somewhat wider. Distichals, as a rule, longer than the costals. They consist in the anterior ray of two series of four plates, which support the arms, the antero-lateral rays have 2×2 distichals followed by three successive palmars in the calyx; while the two posterior rays in one division have four distichals and no palmars, in the other — that adjoining the anal interradius — two distichals and three palmars. The brachials of the two upper rows project outward, and are rounded and grooved laterally at the suture lines. Arm openings sixteen, the interspaces between the rays slightly widest; the arm facet semi-circular, and directed obliquely upward. Arms in pairs, given off in the usual way; they are long, very slender, tapering, and somewhat angular on the back; the joints of medium height, and their upper margins projecting over the lower ones of succeeding pieces. Pinnules long. Anal plate not quite as wide as the radials but higher, and followed by eight to nine interbrachials, against three or four at the other sides, those of the anal side being always, and those of the regular sides sometimes, connected with the plates of the disk. Ventral disk tumid, the centre of the plates covered with a very small tubercle. Anal tube slender, the plates smooth or slightly convex. Column

rather large for the species, the nodal joints projecting and rounded at the edges.

Horizon and Locality.—Upper part of Keokuk group, Crawfordville, Ind., Keokuk, Iowa, and Pike Co., Mo.

Type in the Illinois State collection, Springfield. (The specimen figured on Plate XLVI. is the type of "*Batocrinus Gurleyi*" R. and H.).

***Dizygocrinus montgomeryensis*, var. *unibrachiatus* W. and Sp. (nov. var.).**

Plate XXXIII. Figs. 5, a, b, c.

The above name is proposed for a form very similar to *D. montgomeryensis*, but having single arms in place of double ones. It also closely resembles *D. biturbinatus*; but the specimens are larger, the dorsal cup is proportionally shorter, the arms are longer, less tapering, and placed farther apart.

Horizon and Locality.—Associated with *D. montgomeryensis* in the Upper Keokuk beds, near Keokuk, Iowa.

Types in the collection of Lisbon A. Cox, and Wachsmuth and Springer.

***Dizygocrinus mutabilis* W. and Sp. (nov. spec.).**

Plate XXXV. Figs. 8, 9, 10, 11.

Calyx biturbinate to subglobose; the dorsal cup a little higher than the ventral disk; the plates of the former flat, and the surface without ornamentation or other markings; suture lines slightly grooved.

Basals forming a low basin, hexangular in outline. Radials fully twice as large as both costals together; the upper face concave. First costals very short, linear, the sides convex; the second pentangular with obtuse upper angle. Distichals larger than the costals, increasing in width upward. They are represented by two ranges of three plates in the anterior ray, and also in one of the divisions in the other four rays; while in the opposite division the second piece is axillary, and supports 2×2 palmars, thus giving rise to fourteen arm openings, which bear either single or double arms. Among our seven specimens there is but one in which all the arms are paired. In the six others the paired arms are indiscriminately intermingled with single ones, and in three of these specimens the right antero-lateral ray consists of two pairs, of which one pair rests over the suture line of two adjoining palmars and not upon a distichal. Arms rounded, long, incurving, and composed of rather long transverse pieces. Pinnules flat at the surface, their joints rather short. Regular interbrachials three. The anal plate is consid-

erably higher than the radials, and supports 3, 2, and 1 plate, the latter resting between the arm-bearing palmars. Plates of the tegmen nodose and of uniform size; the anal tube rather stout, and composed of slightly convex pieces, which at intervals are interspersed with tuberculous pieces. Column decreasing in size downward, the joints long.

Horizon and Locality. — Keokuk group; Indian creek, Montgomery Co., Ind.

Types in the collection of Wachsmuth and Springer.

Remarks. — This species resembles *Dizygocrinus biturbinatus* Hall, from which it differs in the arm formula. Specimens in which the arms all are single have not as yet been discovered.

***Dizygocrinus euconus* (MEEK and WORTHEN).**

Plate XXXV. Figs. 7a, b.

1865. *Actinocrinus (Alloprosalloocrinus) euconus* — M. and W.; Proceed. Acad. Nat. Sci. Phila., p. 164.

1873. *Batocrinus (Alloprosalloocrinus) euconus* — M. and W.; Geol. Rep. Illinois, Vol. V., p. 368.

1881. *Batocrinus euconus* — W. and Sp.; Revision Palæocr., Part II., p. 166.

Syn. *Batocrinus subconicus* — WORTHEN; Geol. Rep. Illinois, Vol. VIII., p. 84, Plate 13, Figs. 4 and 4a.

In general form resembling *Alloprosalloocrinus*. Dorsal cup very slightly convex, the sides spreading abruptly from the top of the basals to the arms. Base small, projecting, circular in outline, with a shallow depression for the reception of the column. Surface of plates smooth, without ridges or other elevations. Suture lines indistinct. Radials hexagonal, about twice as wide as high. First costals quadrangular, smaller than the second. Distichals two, followed in the two antero-lateral rays by two rows of two palmars, and four single arms; while the anterior ray, which has an additional distichal at each side, and no palmars, has two arms. The posterior rays have palmars in the division next to the anal side and three arms, there being sixteen arms to the species. Structure of the arms unknown. Interbrachials three at the regular sides, and six above the anal plate, the upper row at all sides arched by the arm-bearing brachials. Ventral disk regularly conical, twice as high as the dorsal cup, composed of rather large, slightly convex pieces; the posterior oral erect, and forming the base of the anal tube. The tube stout at the base and nearly central.

Horizon and Locality. — Warsaw limestone; Spergen Hill, Ind., Union Co., Ills., and Taylor Co., Ky.

Type in the Illinois State collection, Springfield.

Remarks. — Meek and Worthen in 1865 (Proceed. Acad. Nat. Sci. Phila., p. 164), intimated that probably this species was generically, and perhaps specifically, identical with *Alloprosallocrinus conicus*; but neither the one nor the other is the case. That species has twelve arms, and these obviously were given off from the calyx in a very similar manner as the arms of *Agaricocrinus*; while those of *Dizygocrinus euconus*, to judge from the size of the arm facets, were quite slender at their bases.

***Dizygocrinus euconus* var. *abscissus* (ROWLEY and HARE).**

Plate XLVI. Fig. 9.

1891. *Batocrinus abscissus* — ROWLEY and HARE; Kansas City Scient., p. 115, Plate 3, Fig. 6.
 Syn. *Batocrinus venustus* S. A. MILLER; Adv. Sheets 17th Rep. Geol. Surv. Indiana, 1891, p. 67, Plate 11, Figs. 11 and 12.

This form agrees essentially with the preceding one. It is, however, somewhat larger, has twice the number of arms, and the third palmars are incorporated into the calyx, while they are free in the other. There are thirty-two arms in the normal state, which are rather short and slender, and decrease in size upwards. The arm plates are short. Ventral disk decidedly conical, the plates slightly convex.

Horizon and Locality. — Upper part of the Keokuk group, and lower part of the Warsaw limestone; Taylor Co., Ky., and at Boonville and Curryville, Mo.

Type in the collection of Mr. R. R. Rowley, Fort Smith, Ark.

Remarks. — Rowley and Hare's name *Batocrinus abscissus* was published a month in advance of Miller's *B. venustus*.

***Dizygocrinus rotundus* (YAND. and SHUM.).**

Plate XXIX. Figs. 3a-g, and 4.

1848. *Actinocrinites* — Christy's letters on Geology; Plate 1, Figs. 3 and 4.
 1855. *Actinocrinus rotundus* — YANDELL and SHUM.; Geol. Rep. Missouri by Swallow, Part II., p. 191, Plate 4, Figs. 2a, b.
 1873. *Batocrinus rotundus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367.
 1881. *Batocrinus rotundus* — W. and SP.; Revision Palæocr., Part II., p. 168.
 Syn. *Actinocrinus oblatius* HALL; 1860, Suppl. Geol. Rep. Iowa, p. 38.
 Syn. *Batocrinus oblatius* — WHITFIELD; Mem. Amer. Mus. Nat. Hist., 1893, Vol. I., p. 12, Plate 1, Figs. 21, 22.

Form of calyx varying from ovate to depressed globose. Plates flat, the surface perfectly smooth, and the suture lines indistinct.

Basals small, forming a saucer-shaped disk, hexagonal in outline, slightly excavated at the bottom. First costals twice their width, much narrower

than the radials; quadrangular. Second costals a little larger; irregularly pentangular. Distichals in two rows, the upper wider and obtusely axillary. Palmars two, the plates of the upper row smallest, constituting quite frequently a part of the free arms. Arm openings placed at equal distances, except the two facing the anal interradius, which are somewhat farther apart. Arms normally twenty, but varying from eighteen to twenty-two; rather short, slightly flattened at the tips. Interbranchials from three to five, in two or three rows; those of the second row varying in height. The anal interradius generally has four ranges; 3, 3, 3, 2, arched over by the palmars. Ventral disk a little shorter than the dorsal cup, hemispherical; the plates rather large and of nearly uniform size. Anal tube subcentral and comparatively short.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa, Henderson Co., Ills., Palmyra, Mo., and at all localities where rocks of that formation are exposed, this species being one of its most abundant and characteristic fossils.

Remarks. — *Dizygocrinus rotundus* is the most common species of the Burlington group; it occurs most abundantly in the white crystalline layers of the middle part. The number of arms is quite variable, we have specimens with 18, 19, 20, 21, and 22 arm openings. The arms, which are rarely preserved in this species, are simple, there being but one arm to each opening in all our specimens except one, which has a single paired arm in one of its rays.

Hall's "*Actinocrinus*" *oblatus* is a depressed *Dizygocrinus rotundus* with twenty-two arms.

***Dizygocrinus dodecadactylus* (MEEK and WORTHEN).**

Plate XXIX. Figs. 1a, b, c.

1861. *Actinocrinus dodecadactylus* — MEEK and W.; Proceed. Acad. Nat. Sci. Phila., p. 131.

1866. *Actinocrinus (Batocrinus) dodecadactylus* — M. and W.; Geol. Rep. Illinois, Vol. II., p. 205, Plate 15, Figs. 3a, b, c.

1873. *Batocrinus dodecadactylus* — MEEK and WORTHEN; *ibid.*, Vol. V., p. 363.

1881. *Batocrinus dodecadactylus* — W. and SP.; Revision Palæocr., Part II., p. 166.

Probably an early phase of *Dizygocrinus rotundus* in a persistent form. It is a considerably smaller species, and has twelve instead of twenty arms. Calyx globular, the ventral disk as high as the dorsal cup. Plates smooth, suture lines moderately distinct.

Base short, rounded, excavated at the bottom. Radials large, wider than long. Costals small, twice as wide as long, the upper one axillary, support-

ing a single row of large distichals, and these the free arms, except in the posterior rays, in which the plates facing the anal side are axillary, and give off two arms, or three to those rays. Arms delicate; composed of two rows of rather long joints alternately arranged. Anal plate a little longer than wide, contrary to the radials, which are wider than long; it is followed by three and one plate. The other interradii have but one interbrachial, above which the distichals meet. Ventral disk highly convex, composed of but few large plates, of which the orals occupy almost one half of the whole surface. They are surrounded by five large radial plates, between which are interposed two or three smaller interambulacral pieces. Anal tube nearly central, very thin and short.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Type in the Illinois State collection.

Dizygocrinus andrewsianus (McCHESNEY).

Plate XXIX. Figs. 2a, b, c, d.

1860. *Actinocrinus andrewsianus* — McCHESNEY; New Palæoz. Foss., p. 27.

1867. *Actinocrinus andrewsianus* — McCHESNEY; Chicago Acad. Nat. Sci., p. 20, Plate 5, Fig. 5.

1881. *Batocrinus andrewsianus* — W. and Sp.; Revision Palæocr., Part II., p. 165 (Proceed. Acad. Nat. Sci. Phila., p. 339).

A small species. Calyx obconical below the arms, the plates smooth and almost flat; above the arms conical, and the plates convex, sometimes tuberculous.

Basal cup low saucer-shaped, the sides not projecting; the column facet small, interbasal sutures indistinct. Radials of medium size, wider than long. First costals small, quadrangular; the second generally heptangular, a little wider than the first, but not quite as long. Distichals two in all the rays; but in four of them the upper is axillary, and followed by a row of palmars. In the anterior ray, in which there are no palmars, the distichals are somewhat larger, and the second supports the arms. Arm-bearing plates slightly projecting, in contact laterally except at the anal side. Arm openings directed outward. Arms long, infolding, rather thin, not touching each other laterally; they are subcylindrical at their bases, somewhat flattened and wider at the top. The anal plate, which is as large as the radials and of a similar form, is followed by rows of 3, 3, and 2 plates, sometimes with an additional piece in the arm regions. The interbrachials of the four other sides consist of four plates in three rows. The plates of the ventral disk are moderately large and of nearly the same size; the anal tube is sub-central, rather thin and short, not extending beyond the tips of the arms.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Remarks. — This species was described by McChesney as having but four plates in the anal interradius, and three at the other sides. In that case the type specimen was a very young example, in which the upper plates between the rays were as yet undeveloped.

LOBOCRINUS W. and Sp. (nov. gen.).

(Λοβός a lobe; κρίνον, a lily.)

Form of the calyx from pyriform to wheel-shaped; the rays more or less distinctly lobed, and the arms arranged in groups; the ventral disk high, conical or bulging. Plates convex, smooth, or ornamented. Basals three, rather large, forming a subcylindrical cup, which is thickened at the lower end. Radials larger than both costals together; the second costals frequently smaller than the first. Arm facets subcircular, concave, and in some species provided with a transverse imperforate ridge. Arm openings large, directed upward. There are no traces of respiratory pores, but they may have been located close to the edges of the ambulacral openings, some of which are a little excavated at one side. Arms one to each opening; short, cylindrical, and biserial from the base up. Pinnules long. Interbrachials numerous, and in contact with the interambulacrals. Some species have interdistichals. Anal plate succeeded by two interbrachials with a second anal between them, and two or three additional rows of from two to three pieces. The ventral disk is generally large, the anal tube central, stout and very long. Orals well defined, being larger and more nodose than the surrounding plates, especially the posterior one, which is erect, and forms the base of the anal tube at the anterior side of the tegmen. The radial dome plates are large and quite prominent. Column stout, round, and comparatively long; axial canal small and pentangular.

Distribution. — *Lobocrinus*, so far as known, occurs only in America, and is restricted to the Burlington and Keokuk groups.

Type of the genus: *Lobocrinus Nashvillæ* (Troost).

Remarks. — Most species of this genus were originally described under *Actinocrinus*, but were afterwards referred by Meek and Worthen to *Batocrinus*, and one of them to *Uperocrinus*. The latter name had been proposed as a subgenus of *Actinocrinus* with "*Actinocrinus (Uperocrinus) pyriformis*" as type. By placing these species under *Batocrinus*, we should have to ignore the principal character upon which that genus was founded, for in all of

them the interbrachials are continuous with the interambulacral plates. Again *Batocrinus* has well defined, large respiratory pores, which are apparently unrepresented in *Lobocrinus*.

***Lobocrinus Nashville* (TROOST).**

Plate XXXI. Fig. 1.

1849. *Actinocrinus Nashville* — TROOST; Catal. of Crinoidea (Proceed. Amer. Assoc. for Adv. Sci., 1849, p. 60).
 1858. *Actinocrinus Nashville* — Hall; Geol. Rep. Iowa, Vol. I., Part II., p. 609, Plate 15, Fig. 4, and Plate 16, Figs. 4a, b.
 1873. *Batocrinus Nashville* — M. and W.; Geol. Rep. Illinois, Vol. V., p. 363.
 1881. *Batocrinus Nashville* — W. and Sp.; Revision Palæocr., Part II., p. 167 (Proceed. Acad. Nat. Sci. Phila., p. 341).
 1885. *Actinocrinus Nashville* — QUENSTEDT; Handb. der Petrefactenkunde, Plate 77, Fig. 2.
 1890. *Batocrinus Nashville* — WORTHEN; Geol. Rep. Illinois, Vol. VIII., p. 85, Plate 13, Fig. 5.

Calyx higher than wide, urn-shaped, truncated at the base, the lower edge somewhat projecting laterally and rounded off. Dorsal cup higher than the ventral disk, distinctly lobed at the arm regions, contracted at the basi-radial suture, whence it spreads at first gradually, and then rapidly, to the arm bases, which form a projecting rim around the calyx. Plates moderately convex, without ornamentation; the suture lines distinct.

Basals large, forming a subcylindrical cup almost twice as wide as high; the interbasal sutures slightly indented. Radials large, generally wider than long, their median portions raised into a transverse tubercle. Costals one third the size of the radials, a little wider than long; the first quadrangular, the second pentangular. Distichals 2×10 ; followed by 1×20 palmars, which project upward and outward, and support the arms. Arm facets directed upwards. Arms twenty; arranged in pairs, with deep depressions between the rays, and smaller ones between their main divisions. Interbrachials: 1, 2, 2, 2, the last two resting between the arm bases. Anal plate, as a rule, a little higher than the radials; succeeded by three rows of three plates each. Interdistichals one, resting between the second distichals. Orals and radial dome plates — the latter of a first and second order — more or less highly convex, contrasting considerably with the small supplementary pieces surrounding them, which are quite numerous near the arm bases. Anal tube strong, almost central; composed of large tumid plates, which gradually decrease in size upwards. At a height of an inch and a half from the base, the tube has a ring of five spiniferous plates, the spines sometimes nearly an inch long, and directed horizontally. Column stout, and, so

far as observed, of uniform size. To a length of about two inches the joints are of equal length, and there are no internodal joints. But when the latter make their appearance, they increase rapidly to seven to the internode, which seems to have been the maximum number. The upper joints, and the nodal ones below, are rounded at their edges, and project conspicuously beyond the sides of the intervening ones.

Horizon and Locality. — Keokuk limestone; White's Creek Springs, near Nashville, Tenn.; Button Mould Knob, Ky.; Keokuk, Iowa, and Warsaw and Nauvoo, Ills.

Types in the (Worthen) Illinois State collection, Springfield.

Lobocrinus Nashvillæ var. **subtractus** (WHITE).

Plate XXXI. Figs. 2a, b.

1862. *Actinocrinus Nashvillæ* var. *subtractus* — WHITE; Proceed. Bost. Soc. Nat. Hist., Vol. IX., p. 16.
1881. *Batocrinus Nashvillæ*, var. *subtractus* — W. and Sp.; Revision Palæocr., Part II., p. 167.

This variety differs from the typical form in being less strongly lobed at the arm regions, and in having no spines upon the anal tube. The plates of the tube are but slightly convex, and each one is surmounted by a small conical protuberance in the centre. It also differs in the structure of the stem. In specimens from the Burlington limestone, and Burlington and Keokuk Transition bed, the proximal stem joints are shorter than the succeeding ones, and all have an angular edge; while in the specimens from the Keokuk limestone proper the edge is rounded. At three inches from the calyx, all stem joints are nearly of uniform size.

Horizon and Locality. — Upper part of Upper Burlington limestone and Burlington and Keokuk Transition bed; Des Moines Co., Iowa; Henderson Co., and Nauvoo, Ills.

Remarks. — Dr. White gives the absence of the interdistichal piece as the principal distinction between the two forms; this, however, is not a persistent character. We have a number of specimens from the true Burlington beds in which that plate is represented in one or more rays.

Lobocrinus robustus W. and Sp. (nov. spec.).

Plate XXX. Figs. 8a, b.

A large species. Calyx about as high as wide, deeply and broadly depressed between the rays. Dorsal cup but little higher than the ventral disk, the sides slightly convex, constricted at the basi-radial sutures. Plates almost flat and without ornamentation or other markings; suture lines somewhat grooved.

Basals short, projecting; forming a hexagon; excavated at the bottom. Radials large, wider than long, rapidly spreading to two thirds their height, their upper faces deeply excavated in a somewhat similar manner as the facets of the radials in the Platycrinidæ. First costals more than twice as wide as long, subquadrangular; lower and lateral faces convex; the upper ones straight. Second costals longer than the first, their sloping upper faces forming an obtuse angle. Distichals 2×2 ; the first one largest; the second, although an axillary, scarcely angular above. Palmars 2×2 , short, smaller than those succeeding them; the outer ones of the second row separated by interbrachial plates. Arm openings directed upwards, arranged in pairs. Interbrachials three, of which the lower one extends almost to the level of the arm bases; it is extremely large, broad at the bottom, tapering upwards. There are three plates in the second row, of which the middle one rests upon the truncated upper face of the first, the two others against the adjoining sloping faces. Anal plate considerably narrower than the radials; followed by 3, 2, and 1 plate. Ventral disk pyramidal, supporting a nearly central anal tube of moderate width. Plates convex, nodose; the orals very large, especially the posterior one. Structure of arms and column unknown.

Horizon and Locality.—Keokuk group; White's creek Springs, near Nashville, Tenn.

Type in the collection of Wachsmuth and Springer.

Lobocrinus pyriformis (SHUM.).

Plate XXXI. Figs. 3a-e.

1855. *Actinocrinus pyriformis* — SHUMARD; Geol. Rep. Missouri by Swallow, Part II., p. 192, Plate A, Figs. 6a, b.
 1865. *Actinocrinus (Uperocrinus) pyriformis* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 153; also Geol. Rep. Illinois, Vol. II., p. 150.
 1873. *Batocrinus pyriformis* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 375, Plate 5, Fig. 5.
 1881. *Batocrinus pyriformis* — W. and SP.; Revision Palæocr., Part II., p. 167.
 1889. *Batocrinus pyriformis* — NEUMAYR; Die Stämme d. Thierreiches, p. 464, Fig. 134.
 Syn. *Actinocrinus pyriformis*, var. *rudis* — MEEK and WORTHEN; 1860, Proceed. Acad. Nat. Sci. Phila., p. 131.
 Syn. *Actinocrinus (Uperocrinus) pistilliformis* — M. and W.; Geol. Rep. of Illinois, Vol. II., p. 151, Pl. 14, Fig. 8.
 Syn. *Batocrinus pistilliformis* — M. and W.; ibid. Vol. V., p. 367.

A rather large and variable species. Calyx higher than wide, more or less pyriform, and but slightly depressed between the rays. Dorsal cup narrow, and almost cylindrical to the top of the radials — sometimes to the top

of the costals — whence it spreads abruptly to the arm bases. Plates heavy, their middle portions generally prominent, their surfaces smooth, and the suture lines not impressed.

Base once and a half as wide as long, truncated at the bottom, and slightly spreading outward from the lower edge; column facet deeply impressed. Radials large, generally longer than wide, often decidedly so; rising vertically. Costals small; the first quadrangular, not more than one fourth the size of the radials; the second a little wider but not longer than the first. Distichals 2×10 , of the same size as the costals. Each one is followed by two palmars, which either form a continuous series around the calyx, or are separated between the rays by a small interdistichal plate. Arm bases projecting; the arm openings directed obliquely upwards. Arms four to the ray, short, rather flat and heavy. They are composed of two rows of short pieces alternately arranged, which are produced laterally into slender, sharply pointed spines extending out from the sides of the arms. Interbrachial plates 1, 2, 2, followed sometimes by another narrow plate. Anal plate as large as the radials; supporting three smaller plates in the first range, and three in the second, which are frequently followed by one or two other plates. Tegmen conical, slightly bulging; composed of large convex or nodose pieces, which are continued to the anal tube. Orals excentric, and a little larger than the surrounding plates, especially the posterior one. The radial dome plates are also readily distinguished by their larger size and greater convexity. Anal tube almost central, very long and heavy, often rising to three times the length of the arms; it gradually tapers, and has at the upper end a minute opening. Column long, rather stout. It has been observed to the length of twenty inches, to which it neither increases nor decreases in size, and the length of the joints remains unaltered; but the edges of the upper ones are slightly convex, while the lower joints are strictly cylindrical.

Horizon and Locality. — One of the leading fossils of the Upper Burlington limestone, and found wherever that is exposed throughout Iowa, Illinois, and Missouri.

Remarks. — *A. pyriformis*, var. *rudis*, is in our opinion identical with this species. The original specimen was said to come from the Kinderhook group of Marion Co., Ills.; but we doubt it, for it is a true Upper Burlington type.

Lobocrinus spiniferus W. and Sp. (nov. spec.).*Plate XXX. Figs. 11 and 12.*

Of the type of *L. Nashville*, but a smaller species. Dorsal cup generally a little wider than high; from the top of the basals gradually expanding to the arm bases; sides concave. Plates very slightly convex, the radials surmounted by a small central node.

Basal cup twice as wide as high, narrower at the upper end, the interbasal sutures grooved, imparting to the base, as seen from the bottom, a trilobate outline. Radials longer than both costals together, and also broader. The first costals about once and a half as wide as long; the second wider above than below. Distichals two, of the same proportions as the two costals; followed by a single range of palmars, which are larger than any of the preceding brachials, and support the free arms. Arm facets directed obliquely upwards. Arms arranged in pairs; those of different rays separated at their bases by one or two interbrachials, those between their main divisions by a single interdistichal. Arms short, cylindrical, very little tapering, and curving inward; they are composed of two rows of transverse pieces, alternately arranged and slightly interlocking. Pinnules very long, in close contact; composed of elongate flat joints. Interbrachials: 1, 2, 2, 1; the first larger than any two of the others, the upper placed at the arm regions. Anal plate somewhat taller but narrower than the radials; followed by 3, 3, 2, and 2 plates. The construction of the disk not visible in any of the specimens. Anal tube long, observed to an inch above the tips of the arms, but evidently longer. It is composed of convex, slightly nodose plates, but at a height nearly corresponding to the tips of the arms there are from seven to eight plates with sharp, slender spines, 5 to 6 mm. long, which stand out horizontally from the sides.

Horizon and Locality. — Keokuk group; Indian creek, Montgomery Co., Ind.

Types in the collection of Wachsmuth and Springer.

Remarks. — There is a slight possibility that *Batocrinus marinus* Miller and Gurley is identical with this species. We were unable to make satisfactory comparison either with the description or figure.

Lobocrinus æquibrachiatus (McCHESNEY).*Plate XXIX. Figs. 8a, b, and Plate XLVI. Figs. 6a, b.*

1860. *Actinocrinus æquibrachiatus* — McCHESNEY; New Palæoz. Foss., p. 25.
 1867. *Actinocrinus æquibrachiatus* — McCHESNEY; Trans. Chic. Acad. Sci., p. 18, Plate 4, Figs. 2 and 5.
 1873. *Batocrinus æquibrachiatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 368.
 1881. *Batocrinus æquibrachiatus* — W. and SP.; Revision Palæocer., Part II., p. 165.

Intermediate between *Eutrochocrinus Lovei* and *Lobocrinus pyriformis*; differing from the former in the much broader base, and in having the arm bases directed upwards and arranged in groups; from *L. pyriformis* in the less elongate calyx, in the depressed form of the ventral disk, the comparatively longer arms, and in the shorter and more slender anal tube; and from both in being decidedly lobed between the rays. Calyx as high as wide; the dorsal cup one third higher than the ventral disk, broadly truncated at the base, the sides concave, gradually widening to the top of the first costals, thence rapidly spreading to the arm facets, which are directed upward. Plates of the dorsal cup perfectly flat and smooth, those of the ventral disk more or less convex.

Basals forming a nearly cylindrical cup, more than twice as wide as high; interbasal sutures indistinct. Radials nearly as long as wide, the upper end a little wider. First costals quadrangular, once and a half as wide as long; the second fully twice as wide as long, heptangular; their upper angles obtuse. Distichals 2×2 , the second axillary and larger than the other brachials; followed by a single row of palmars, which support the arms. Arm openings arranged in groups of two, the interspaces larger between the main rays than between their subdivisions. Arms twenty, of moderate size and length, frequently infolding at the top, which makes them appear shorter than they really are. Interbrachials from five to nine, generally continuous with the interambulacral plates at all sides, but always at the posterior side. Anal interradius composed of ten to fourteen pieces; the anal plate higher than the radials; followed by three ranges of three plates each, and a few narrow pieces interposed between the arm bases. Ventral disk depressed conical, the plates rather large and of almost equal size. Anal tube nearly central, composed of tumid plates.

Horizon and Locality. — Lower part of the Upper Burlington limestone, Burlington, Iowa.

Lobocrinus æquibrachiatus var. **asteriscus** (MEEK and WORTHEN).*Plate XXIX. Figs. 9a, b.*

1860. *Actinocrinus asteriscus* — MEEK and WORTHEN; Proc. Acad. Nat. Sci. Phila., p. 385.
 1866. *Actinocrinus asteriscus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 207, Plate 15, Figs. 8a, b, c.
 1873. *Batocrinus asteriscus* — MEEK and WORTHEN; Ibid., Vol. V., p. 368.
 1881. Syn. of *Batocrinus æquibrachiatus* — W. and Sp.; Revision Palæocr., Part II., p. 165.
 Syn. *Actinocrinus æquibrachiatus*, var. *alatus* HALL; Boston Journ. Nat. Hist., p. 263, Photogr. Plate 3a, Figs. 21-23; and Whitfield; Amer. Mus. Nat. Hist., 1893, Vol. I., p. 11, Plate 1, Fig. 14.

This variety differs from the typical *Lobocrinus æquibrachiatus* in the shortness of the calyx, the flatness of the ventral disk, in being more deeply lobed at the arm bases, in the larger size of the costals, and in the condition of the interbrachial and interambulacral plates, which are in contact at all sides.

Horizon and Locality. — Upper Burlington limestone, Burlington, Iowa.

Type in the (Worthen) Illinois State collection, Springfield.

Lobocrinus Yandelli (SHUMARD).*Plate XXX. Figs. 7a, b.*

1857. *Actinocrinus Yandelli* — SHUMARD; Trans. St. Louis Acad. Sci., Vol. I., p. 76, Plate 1, Figs. 4a, b, c.
 1873. *Actinocrinus Yandelli* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 341.
 1881. *Batocrinus Yandelli* — W. and Sp.; Revision Palæocr., Part II., p. 168.

A large, very knobby and rugose species. Calyx depressed; the ventral disk from one fourth to one third higher than the dorsal cup, the latter abruptly spreading from the top of the basals to the bases of the free arms, forming a low cup or basin, which is followed by a conical disk. The interrarial spaces are deeply depressed between the rays at the arm bases, especially the posterior one which also is wider. The surface of the plates is covered by prominent knobs, either transversely or longitudinally arranged.

Base short, truncated at the bottom; the lower margins projecting outwards and considerably thickened; the upper faces deeply emarginated toward the sutures, and the suture lines distinctly grooved, giving to the base, as seen from below, a decidedly trilobate aspect. The column facet occupies one half the width of the base, and is slightly impressed, its surface crenulated at the margin. Radials twice as wide as long; their upper faces a little concave; the upper sloping faces rather short. The plates

are covered with conspicuous, transversely curved prominences, which are studded with two or three irregular nodes. First costals considerably smaller than the radials; the second smaller than the first, in some specimens pentagonal, in others trigonal. Distichals 2×2 , larger than the costals, especially the upper or axillary ones, which are almost as wide as the radials. Palmars 2×4 , larger than the distichals. They support the arms invariably in three of the rays, but in the two posterior rays the second plate adjoining the anal side is frequently axillary and followed by postpalmars. The distichals are not placed on a level with their fellows of the same ray, but are alternately arranged, and the same is the case with the two inner rows of palmars; the arm-bearing plates being placed horizontally. The brachials throughout the calyx are covered with elongate elevations, and these again by a row of small nodes. Arms twenty to twenty-two; their structure unknown. Interbrachials: 1, 2, 1, and 2 between the arms; the first wider than long, its node transversely elongate; the two of the second range longer than wide, and the nodes disposed longitudinally. The anal plate, which is longer than the radials, followed by three plates — the two at the sides wider than the middle one — and by three irregular smaller pieces, which in turn support several rows of elongate interambulacra. The plates of the tegmen increase in size as they approach the middle; they are heavy, proportionally large, and the centre of each is crowned with a small tubercle. The anal tube is almost central, stout, and apparently long.

Horizon and Locality. — Keokuk group; Button Mould Knob, seven miles from Louisville, Ky.

Types in the Yandell collection at Louisville, Ky.

***Lobocrinus longirostris* (HALL).**

Plate XXVIII. Figs. 1a-e.

1858. *Actinocrinus longirostris* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 589, Plate 11, Figs. 4c, d, and 2.
 1873. *Batocrinus longirostris* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367.
 1881. *Batocrinus longirostris* — W. and SP.; Revision Palæocr., Part II., p. 167.
 Syn. *Batocrinus casedayanus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 370, Plate 5, Figs. 1a, b.

Of medium size. Calyx ovate, higher than wide; the dorsal cup higher than the ventral disk; the arm bases a little projecting. Plates more or less

convex ; in some species quite prominent and the surface slightly rugose, in others almost flat and perfectly smooth. Suture lines grooved.

Base short, hexagonal in outline, rounded at the bottom, the column facet slightly excavated, the interbasal sutures impressed. Radials wider above than below, deeply notched for the reception of the first interbrachial, the upper face concave. Costals rather large for the genus, together about equal to the size of the radials ; the upper larger and generally heptagonal. Distichals two, smaller than the costals, the axillaries supporting 2×2 palmars, and normally four arms to the ray ; frequently, however, the anterior ray has but two or three arms, and an additional fixed distichal in place of palmars. Arm openings directed obliquely upwards ; the interspaces separating the rays a little wider and deeper than those between the openings of the same ray. Arms from eighteen to twenty, long, rounded on the back, gradually tapering but not infolding, and composed from the calyx up of two rows of transverse pieces. Pinnules long and cylindrical. Interbrachials from five to seven ; the lower wider than long, and generally not rising to the full height of the second costals. There are two comparatively large plates in the second row, and one in the third, followed by one or two irregular pieces, which separate the rays at the arm bases. Anal plate considerably longer than the radials, supporting three plates in the first, and three to four in the second range ; the succeeding ones irregularly arranged and interlocking with the interambulacral plates. Ventral disk depressed conical. Orals and radial dome plates a little larger than the interambulacral pieces ; arranged in the usual way. Anal tube stout and very long, rising in some specimens as much as 6 cm. beyond the tips of the arms ; the plates smooth. Column round, of medium size, the nodal joints rounded at the edges, the others considerably narrower near the calyx, but attaining the same width farther down.

Horizon and Locality. — Lower Burlington limestone ; Burlington, Iowa, and at several places in Missouri.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — We regard *Batocrinus casedayanus* M. and W., as a mere variation of this species ; the plates, although more convex than in the typical form, are arranged in exactly the same way.

Lobocrinus inflatus (ROWLEY and HARE).*Plate XXXIV. Figs. 18, a, b.*

1891. *Batocrinus inflatus* — ROWLEY and HARE; Kansas City Scient., p. 102, Plate 2, Fig. 19.
 Syn. *Batocrinus bulbosus* — ROWLEY and HARE; *ibid.*, p. 114, Plate 3, Fig. 5.

Calyx about as high as wide, small, subglobose, slightly flattened at the anal side. Dorsal cup more than twice as high as the ventral disk, deep bowl-shaped; the plates heavy, almost flat and devoid of ornamentation; the suture lines somewhat grooved.

Basals a little projecting, forming a low cup with a shallow concavity at the bottom. Radials wider than long, as large as both costals together. First costal quadrangular, small, wider than high. The second costal generally heptangular, considerably larger than the first, wider as well as longer. Distichals two, rather large, those of the anterior ray, and the outer ones of the posterior rays, supporting directly the arms; while the inner ones bear a palmar on each side. The anterior rays of the type specimen are abnormal; the ray to the right is formed like the anterior one, and has but two arms, that to the left supports palmars on both distichals, and has four arms.* Arm facets somewhat projecting and deeply concave; they point slightly upwards, and are arranged in groups. Interspaces between the rays wider than those between the main divisions of the rays, and considerably wider than the spaces between arms of the same division. There are no respiratory pores near the arm openings. Arm structure unknown. Regular interbrachials: 1, 2, 2; the first very large, as wide as high; the two upper ones interposed between the arm-bearing pieces, and followed by disk plates. The anal plate supports: 3, 3, 2, and one plate, the latter being designated more properly as a plate of the disk. Ventral disk small, the anal tube occupying almost one third of its diameter; the plates nodose, and of nearly uniform size, even the orals cannot be distinguished. Anal tube heavy at the base and central.

Horizon and Locality. — Lower part of the Lower Burlington limestone, Louisiana, Mo.

Types in the collection of Mr. R. R. Rowley.

* In another fragmentary specimen in Mr. Rowley's collection, the right antero-lateral ray, the only one seen, has three arm openings, one above the distichals, the two others above a palmar. This is probably the normal arrangement, and there are fourteen arms to the species. The type of *B. bulbosus* curiously also has but two arms to the right and four to the left.

Remarks.—We regard *Batocrinus bulbosus* R. and H. as identical with this species, although the type specimens show slight variations. The disk of "*B. bulbosus*" is somewhat more depressed, due perhaps to outside pressure, and the plates of the disk are less convex; but variations of this kind are known to occur within the limits of almost every species. The two specimens agree essentially in the arrangement of their plates, in the mode of branching of the arms, they have the same number of interbrachials, and these connect in both forms with the plates of the disk.

(?) **Lobocrinus Hageri** (McCHESNEY.)

Plate XXX. Figs. 9, 10.

1860. *Actinocrinus Hageri* — McCHESNEY; New Palæoz. Foss., p. 28.
 1867. *Actinocrinus Hageri* — McCHESNEY; Chicago Acad. Nat. Sci., p. 21, Plate 4, Fig. 1.
 1873. *Batocrinus Hageri* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367.
 1881. *Batocrinus Hageri* — W. and SP.; Revision Palæocr., Part II., p. 166.

Approaching *Dizygocrinus rotundus*, but the dorsal cup more conical and proportionally higher; slightly depressed between the rays; the anal tube smaller and more excentric. Plates flat, without ornamentation, and the suture lines indistinct.

Basals forming a low saucer-shaped, hexagonal disk, rounded at the bottom, and excavated for the columnar attachment, which is small. Radials half as wide again as long. First costals quadrangular, three times as wide as long, the second wider than the first. Distichals in two rows, those of the upper row wider and axillary; followed by 2×2 palmars, which support the free arms. Arm openings directed obliquely upwards, arranged in groups of four, with a slight indentation between the rays, of which that at the posterior side is considerably the deeper. Arm structure unknown. Interbrachials: 1, 2, 2, 2, the upper row in contact with the plates of the ventral disk; the first plate smaller than usual in this genus, and frequently not reaching to the full height of the second costals. Anal plate a little smaller than the radials; succeeded by 3, 3, 2, and 2 plates. Ventral disk slightly grooved at the posterior side, depressed convex, the plates nearly flat and almost equal in size. Anal tube excentric, very narrow and short.

Horizon and Locality. — Upper Burlington limestone, Burlington, Iowa.

Type in the (Worthen) Illinois State collection.

Remarks. — We have placed this species somewhat reluctantly under

Lobocrinus, from the typical form of which it differs in having a diminutive anal tube, which occasionally is reduced to a mere opening from the tegmen, similar to that of *Dorycrinus*. It departs from *Batocrinus* in the same character, and in being distinctly lobed between the rays, the plates forming the arm bases are separated by interbrachials, and the arm openings are directed upwards; in all of which it agrees with *Lobocrinus*.

MACROCRINUS W. and SP. (nov. gen.).

(Μακρός long, κρίνον a lily.)

Calyx biturbinate or subovoid, the plates in part elevated. It may be pointed out as a structural peculiarity of this genus, that the radials, anal plate, and first interbrachials are generally nodose, but the higher brachials and interbrachials almost flat and devoid of all markings.

Basals rather large, forming a subcylindrical cup. Radials frequently larger than both costals together. Costals quadrangular and pentangular. The number of distichals variable. Arm-bearing plates in contact laterally, except at the posterior side, where they are separated by a small interbrachial plate. Arm openings directed outward. Respiratory pores in five pairs, placed interradially. Arms from twelve to sixteen, long, subcylindrical; tips incurving and sometimes flattened, but without increasing in width. Regular interbrachials not numerous; the anal plate generally supporting two rows of three plates, and a small piece within the arm regions. Ventral disk shorter than the dorsal cup, composed of comparatively few large plates. Anal opening at the end of an unusually long tube, reaching far beyond the tips of the arms; it is almost central, straight, stout at the base, but gradually tapers upwards so as to be quite slender at the end.

Distribution. — So far as known restricted to America, and found only in the Upper and Lower Burlington beds, and in the lower part of the Keokuk group.

Type of the genus: *Macrocrinus Konineki* (Shumard).

Remarks. — The species for which we propose this genus have been referred successively to *Actinocrinus*, *Batocrinus*, and *Eretmocrinus*, but, as generally admitted, without agreeing with either one of them. They differ from *Batocrinus* in the more elongate form of the calyx, the less number and greater length of the arms, and in having but five pairs of respiratory pores; and from *Eretmocrinus* in the arm structure, and in having a long, straight, and almost central anal tube.

Macrocrinus Konincki (SHUM.).*Plate XXXV. Figs. 1, 2, 3.*

1855. *Actinocrinus Konincki*—SHUMARD; Geol. Rep. Missouri by Swallow, Part II., p. 194, Plate A, Figs. 8a, b, c.
 1873. *Batocrinus Konincki*—MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 367.
 1877. *Batocrinus Konincki*—S. A. MILLER; Catal. Amer. Palæoz. Foss., p. 172.
 1881. *Eretmocrinus Konincki*—W. and SP.; Revision Palæocr., Part II., p. 173 (Proceed. Acad. Nat. Sci. Phila., p. 347).
 1890. *Eretmocrinus Konincki*—S. A. MILLER; North Amer. Geol. and Pal., p. 243.
 Syn. *Actinocrinus urnæformis*—MCCHESNEY; 1860, Descr. New Spec. of Foss., p. 23.

Calyx urn-shaped, small, elongate. Dorsal cup one third higher than the ventral disk, constricted at the basi-radial sutures, whence it gradually and uniformly expands to the bottom of the arm-bearing brachials, which are directed abruptly outward. All plates of the dorsal cup are more or less convex; the radials, anal plate, and first interbrachials strongly nodose.

Base rather high, wider at the lower end than at the upper; the bottom truncated and hexangular in outline; interbasal sutures indistinct; the column facet bordered by a small circular ridge. Radials large, as long as wide. The two costals together not more than half the size of the radials; the first as long as wide, or nearly so, and quadrangular; the second larger, more convex, and pentangular. The three anterior rays have 3×2 distichals and two arms; the two posterior rays toward the anal side but one distichal, followed by 2×2 palmars, at the opposite side three successive distichals. The two upper rows of brachials in the calyx are connected laterally except at the anal side, where one or two small plates are interposed between them. Arm facets small; the ambulacral openings slightly grouped; the space between the posterior rays wider than between the others, and somewhat depressed. Respiratory pores arranged interradially; they consist of five pairs, are very large, and are located on a level with the ambulacral openings. Arms twelve, biserial, of moderate length, the tips infolding; they are slender, slightly flattened on the back, and composed of short, narrow, transverse pieces. There is but one interbrachial at the four regular sides, but four to six in the anal interradius. The anal plate is higher than the radials, and followed by three large nodose plates, and by one, two, or three in the next row. Ventral disk irregularly conical, the posterior oral pushed anteriorly, very large and more elevated than any of the other plates. Anal tube almost central, and composed of large, nodose pieces; it

is long, stout at the base, but quite thin at the upper end. Column slender, the joints high.

Horizon and Locality. — Lower part of the Upper Burlington limestone, Burlington, Iowa.

Type in the Washington University Museum at St. Louis.

Macrocrinus carica (HALL).

Plate XXXVII. Fig. 8.

1861. *Actinocrinus carica* — HALL; Prelim. Descr. New Crin., p. 10.
 1873. *Batocrinus (Eretmocrinus) carica*; MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 368.
 1877. *Batocrinus carica* — S. A. MILLER; Amer. Palæoz. Foss., p. 71.
 1881. *Eretmocrinus carica* — W. and SE.; Revision Palæocr., Part II., p. 172 (Proceed. Acad. Nat. Sci. Phila., p. 346).
 1890. *Eretmocrinus carica* — S. A. MILLER; North Amer. Geol. and Pal., p. 243.

Larger than the preceding species, and more robust. Calyx longer than wide, ovoid; the dorsal cup one third to one half higher than the ventral disk. All principal plates of the calyx strongly nodose, the others flat or slightly convex; the suture lines obscure.

Basals directed downward, deeply notched at the sutures, and slightly at the middle of each plate, so as to form six angularities or small nodes at the lower end of the base; the bottom forming a deep concavity, containing several joints of the column. Radials very large, wider than long, extended into a long transverse node which is directed obliquely downward. First costals small, almost linear, their surfaces flat; the second are nodose, pentangular, longer than the first, and somewhat wider. Distichals 3×2 in the three anterior rays; in the two posterior ones the divisions next to the anal side have only one distichal, which supports two palmars from each side; the other divisions have three distichals and no palmars, which gives twelve arms to the species. The distichals and palmars join laterally; the plates are flat, except the arm-bearing ones, which are rounded like arm plates and project outward. Arm facets a little concave, directed horizontally; the ambulacral openings almost equidistant; the respiratory pores restricted to the inter-radial spaces. Structure of the arms not known. There is but one regular interbrachial plate, the anal side has three above the anal plate, all of which are strongly nodose. Ventral disk hemispherical, constructed almost exclusively of the orals and radial dome plates, which are large and tuberculous. There are at each interradius three or four interambulacral pieces, which are scarcely convex. Anal tube slightly excentric, rather slender, its length unknown.

Horizon and Locality. — Upper Burlington limestone, Burlington, Iowa.

Types in the Museum of Comparative Zoölogy.

Remarks. — This rare and beautiful species is readily recognized by the peculiar form of its base, the large nodes upon the radials and interbrachials, and the flat plates in the upper part of the dorsal cup. The nodes upon the radials hang downward, and their extremities reach almost to a line with the lower end of the basals.

Macrocrinus gemmiformis (HALL).

Plate XXXVI. Fig. 8.

1860. *Actinocrinus gemmiformis* — HALL; Suppl. Geol. Rep. Iowa, p. 23 (Photogr., Plate 3A, Fig. 6, 1872, N. Y. State Museum, Bull. I.).
 1873. *Batocrinus* (*Eretmocrinus*?) *gemmiformis* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 368.
 1877. *Batocrinus gemmiformis* — S. A. MILLER; Catal. Palæoz. Foss., p. 72.
 1881. *Eretmocrinus gemmiformis* — W. and SP.; Revision Palæocr., Part II., p. 173.
 1890. *Eretmocrinus gemmiformis* — S. A. MILLER; North Amer. Geol. and Palæont., p. 243.

A small and delicate species. Calyx a little higher than wide. Dorsal cup truncate at the bottom; the sides moderately and uniformly rising to the arm bases; higher than the ventral disk. Plates elevated; the radials covered with long transverse nodes or obtuse spines, and similar elongate nodes, but circular in outline, are formed on the second costals, the first interbrachials, and the anal plate; the distichals and palmars angular on the back, forming distinct ridges.

Basals produced into long spreading extensions, which overhang the upper part of the column, giving to the base a decidedly trilobate outline. Radials large, a little wider than long. Costals less than half the size of the radials, almost as long as wide; the first quadrangular; the second pentangular. The anterior ray has 3×2 distichals; the four other rays have in one division two small distichals, followed by two palmars, in the other three distichals. There are fourteen arms to the species, exceptionally fifteen or sixteen, the odd number occurring in the antero-lateral rays. The upper brachials are in contact laterally except on the anal side, where they are separated by an elongate piece, which connects with the plates of the disk. Structure of arms unknown. Anal plate higher than the radials, supporting three large plates, and these from two to three small ones; the interbrachials at the four regular sides consist of two to three plates. Ventral disk hemispherical; the plates large and sharply nodose. The posterior oral forms at

the anterior side the base of the ventral tube, which is almost central, and more slender than usual in this genus.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — The specimen from which Hall made his description was defective, and the arm formula which he gives of the species is incorrect. It has normally but fourteen arms: $\frac{1}{2}\frac{1}{2}$; but when an additional arm is introduced, which is quite often the case, this is placed in the antero-lateral rays, and not in the posterior one. Hall gave the arm formula as $\frac{1}{2}\frac{1}{2}$.

Macrocrinus verneuillianus (SHUM.).

Plate XXX. Figs. 15, 16, 17, 18.

1855. *Actinocrinus verneuillianus* — SHUMARD; Geol. Surv. of Missouri by Swallow, Part II., p. 1933, Plate A, Figs. 1a, b.
 1873. *Batocrinus verneuillianus* MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 379, Plate 4, Figs. 3 and 4.
 1881. *Eretmocrinus verneuillianus* — W. and SP.; Revision Palæocr., Part II., p. 173 (Proceed. Acad. Nat. Sci. Phila., p. 347).
 1890. *Eretmocrinus verneuillianus* — S. A. MILLER; North Amer. Geol. and Palæont., p. 243.

Calyx biturbinate, higher than wide; the dorsal cup higher than the ventral disk, truncate at the base, its sides a little concave, the arm-bearing plates projecting. Surface of plates flat or very slightly convex, the radials and first interbranchials always more or less elevated at the median portions.

Basals rather large, forming a hexagonal cup with erect sides; grooved at the interbasal sutures; the column facet deep and narrow, occupying but one third the diameter at the bottom of the calyx. Radials twice as large as the two costals together, somewhat variable in form, but generally as long as wide, and the lateral faces considerably longer than the upper sloping faces; the two heptagonal plates larger than the hexagonal ones. First costals quadrangular, very small, twice as wide as long; the second somewhat larger and pentangular. Distichals two in both divisions of the anterior ray, and also in one division of the other rays; the other division has but one distichal, which is axillary, and supports 2×2 small palmars; there being normally fourteen arms, with variations from fourteen to eighteen. First palmars in lateral contact with each other and with adjoining distichals, except at the anal side; while the upper plates meet only their fellows of the same ray, being entirely free at one side. Arm openings directed slightly upwards; the interspace between the posterior rays wider

than those between the other rays, and much more depressed. Respiratory pores large, in five pairs, placed interradially. Arms long, the tips infolding; composed of two series of moderately long pieces. Near the upper end the arms, which below are rounded on the back, grow almost flat, however, without increasing in width, and the surface of each plate in well preserved specimens is covered with two small nodes which, formed into longitudinal rows, give to the upper part of the arm a file-like appearance. Pinnules long, composed of elongate joints, each one provided with a small hook at the upper face. Regular interbrachials from one to three. Anal plate higher than wide, followed by 3, 3, and 1 plate, the latter piece resting between the arm-bearing brachials. Plates of the ventral disk almost flat, except the posterior oral, which is moderately convex and very large; it is erect, and forms at the anterior side the base of the anal tube. The tube is almost central, very stout at the base, extremely long, attaining sometimes twice the length of the arms, and it terminates in a very slender point. The stem, which is known to a length of about 15 cm., retains nearly the same width throughout. To the length of about 5 cm., smaller joints alternate at intervals with larger ones, thence downward the plates gradually become uniform. The larger or nodal joints throughout the stem are about 1 mm. high by less than 2 mm. wide. Toward the lower end appear cirri, given off irregularly, and only one from a plate. Axial canal small, pentagonal.

Horizon and Locality. — Upper Burlington limestone. It is found wherever this bed is exposed throughout Iowa, Illinois, and Missouri, being one of the two most common Crinoids of this horizon, and very characteristic of it.

Macrocrinus jucundus (M. and G.).

Plate XXX. Figs. 13, 14.

1890. *Batocrinus jucundus* — MILLER and GURLEY; Journ. Cincin. Soc. Nat. Hist., Vol. XIII., p. 20, Plate 4, Figs. 5 and 6.

Syn. *Batocrinus agnatus* — S. A. MILLER; Adv. Sheets 17th Rep. Geol. Surv. Indiana, 1891, p. 53, Plate 8, Figs. 1 and 2.

A small species, the calyx subovoid. Dorsal cup higher than the ventral disk, truncated at the bottom; the sides moderately convex; the arm-bearing plates projecting outward. The plates in most of the specimens are almost flat; in some, however, the middle part of the radials is formed into a

short, transverse node, and the lower portions of the first interbrachials are slightly thickened.

Basals large, constituting a short cylindrical cup, fully twice as wide as the column, sometimes slightly expanding at the lower end, and hexagonal in outline. Radials much larger than the two costals together, wider than long, the lateral faces considerably longer than the sloping upper ones, the upper faces slightly concave. First costals quadrangular, one third wider than long; the second pentangular, wider and longer than the first. Distichals 2×2 throughout the calyx, but those of the anterior ray are succeeded directly by the arms; while in the posterior rays, in the division next to the anal side, and in both divisions of the antero-lateral rays, the second distichals are axillary, and support a palmar from each side. Arm openings directed slightly upwards; almost equidistant; the arm-bearing plates in contact laterally, except those facing the anal side, which are separated by a narrow, elongate plate. Arms sixteen, moderately long, rounded on the back, gradually tapering to the tips, and composed from their bases up of two series of rather long pieces. Pinnules long, the joints elongate. Interbrachials two to three, those of the second row comparatively large. At the anal side also, the upper plates are large for this genus; the anal plate is higher than the radials, and succeeded by three plates, which are as high and almost as wide as the corresponding single plate at the other sides; the three plates of the second row are fully as large as the axillary distichals. Ventral disk conical, the plates large, nodose, and extended into a long central tube, which reaches far beyond the tips of the arms. The tube is stout at the base, but gradually tapers to a sharp point at the end, and is composed of similar plates as the disk. The posterior oral is pushed far out to the anterior side; it is three times as large as the four others, more prominent, and arranged transversely. Column small, the nodal joints rather high, with rounded edges, and wider than the intervening ones. At 4 cm. from the calyx the last internode contains seven pieces.

Horizon and Locality.—Keokuk group; Indian creek, ten miles from Crawfordsville, Montgomery Co., Ind., where it was found by us in large numbers and in excellent preservation.

Remarks.—*Batocrinus agnatus* S. A. Miller, is identical with this species, with only two arms in the anterior ray in place of three.

Macrocrinus lagunculus (HALL).*Plate XXXV. Fig. 4.*

1860. *Actinocrinus lagunculus* — HALL; Suppl. Geol. Rep. Iowa, p. 41.
1867. *Batocrinus lagunculus* — M. and W.; Geol. Rep. Illinois, Vol. V., p. 367.
1881. *Batocrinus lagunculus* — W. and SP.; Revision Palæocr., Part II., p. 166.

A very small species of the type of *Macrocrinus verneuillianus*, but the dorsal cup proportionally longer, and the arm openings formed into an almost continuous ring around the calyx. Calyx once and a half as high as wide. Dorsal cup conical, as high as the width at the arm bases; the sides a little convex. Surface of plates slightly elevated, and beveled at the margins.

Basals moderately short, thickened at their lower margins, and forming a rim, which is not indented at the sutures. Radials longer than wide, the superior faces concave. First costals twice as wide as long, quadrangular; second costals pentagonal, exceptionally hexagonal in the postero-lateral rays. The anterior ray has 3×2 distichals and two arms; the antero-lateral but one distichal and four arms; while the two postero-lateral ones, which sustain three arms, have toward the anal side a distichal and two palmars, and at the opposite side three distichals, making sixteen arms to the entire species. First anal plate as large as the radials, slightly longer but narrower; the second anal a little larger than the two interbrachials aside of it. The next row consists of two or three pieces. The four regular sides contain three plates, which are arched by the arm-bearing brachials, and also those of the posterior side. Tegmen conical, gradually passing into the anal tube, which is very stout; plates nodose, decreasing in size as they approach the arm-bases. Orals excentric; the posterior one standing erect, to one side of the anal tube.

Horizon and Locality.—Keokuk group; Warsaw, Ills., and Keokuk, Iowa.

Type in the Illinois State collection, Springfield.

DORYCRINUS ROEMER.

1854. F. ROEMER; Archiv. f. Naturgesch., Jahrg. XIX., Band 1, p. 207.
 1855. F. ROEMER; Lethæa Geogn. (Ausg. 3), p. 249.
 1869. MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 165.
 1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 379.
 1878. W. and SP.; Proceed. Acad. Nat. Sci. Phila., p. 264.
 1879. ZITTEL (subgenus of *Amphoracrinus*); Handb. der Palæont., Vol. I., p. 370.
 1881. W. and SP.; Revision Palæocr., Part II., p. 176 (Proceed. Acad. Nat. Sci. Phila., p. 350).
 Syn. *Amphoracrinus* MEEK and WORTHEN (not Austin, 1866), Geol. Rep. Illinois, Vol. II., p. 209.

Calyx decidedly bilateral, distinctly lobed at the arm regions, the interradial spaces deeply depressed and sinuous. The dorsal cup broadly truncate at the bottom, the plates heavy and frequently nodose. Basals three, large, their sides produced into a rim which sometimes becomes highly conspicuous. Radials, as a rule, as large as the two costals together. First costals quadrangular; the second usually pentangular, exceptionally hexangular or heptangular. Distichals two when there are no palmars, but when the latter are represented, there is but one distichal, which is axillary, and is followed by a single row of palmars. Arms in pairs, given off from a minute axillary, which occupies the same facet with the proximal arm plates at each side, and both arms have a common ambulacral opening in the calyx. In species with twenty arm openings, each ray has four pairs of arms, but when there are less than twenty, the antero-lateral rays generally have but two pairs, and the anterior one from two to four. The arms are rather short, biserial, and more or less spinous. The spines are given off at intervals from the sides, and are formed by the outward prolongation of the arm plates. Pinnules of moderate size. The number of interbrachials is limited, there being rarely more than three in the dorsal cup, the two upper ones at the level of the arm bases. The anal side is more or less flattened, the median line elevated, the sides grooved. It consists of a longitudinal row of anal plates, supporting a number of smaller pieces, which surround the anus. At each side of the anal row there are one or more interbrachials, somewhat depressed below the level of the anal plate between them. Ventral disk highly elevated; the posterior oral, and frequently also the first radial plates above the ambulacra, extended into low spines. Anus eccentric, opening out laterally directly from the disk. Column round, the nodal joints largely projecting over the others; axial canal small, pentangular.

Distribution. — So far as known, restricted to the two Burlington beds, and the Keokuk limestone.

Type of the genus: Dorycrinus mississippiensis Roemer.

Remarks.—In the Revision, Part II., we referred to this genus *Dorycrinus canaliculatus* and *Actinocrinus* (*Celocrinus*) *concavus* Meek and Worthen, *Actinocrinus subaculeatus* Hall, and *A. parvus* Shumard, all of which we have now arranged under a new genus *Aorocrinus*, along with *Dorycrinus immatursus*, *D. parvibasis*, and *D. radiatus*, described by us in Vol. VIII. of the Geological Report of Illinois. The arms of those species, instead of being paired, are stouter and single, the first radial plates in the disk are not spiniferous, nor in any way distinct from the surrounding pieces, and their basals are small and rounded at the lower margins.

***Dorycrinus mississippiensis* ROEMER.**

Plate XLIII. Fig. 1, and Plate XLIV. Figs. 2, 3.

1854. ROEMER; Archiv. f. Naturg. (Jahr. XIX.), Band I., p. 213, Plate 10.
 1862. DUJARDIN and HUPÉ; Hist. natur. des Zoophytes Échinod., p. 143, Plate 3, Figs. 1-3.
 1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 380.
 1881. W. and SP.; Revision Palæocr., Part II., p. 179 (Proceed. Acad. Nat. Sci. Phila. p. 353).
 Syn. *Actinocrinus* (*Dorycrinus*) *mississippiensis*, var. *spiniger* HALL; Suppl. Geol. Rep. Iowa, 1859, p. 53.

A large species. Calyx about as high as wide, asteriform in its ventral aspect, deeply impressed and flattened at the posterior side, broadly truncate at the lower end; the ventral disk extended into six long, heavy spines; the plates from almost flat to strongly nodose; suture lines more or less grooved.

Basals large, forming a cup which is three times as wide as long, slightly expanding to the lower margin, flat at the bottom, with a shallow depression for the attachment of the column. Radials once and a half to twice as wide as long, the upper face concave. First costals comparatively large, wider than long, quadrangular. Second costals a little larger than the first; those of the posterior rays generally hexangular, the others heptangular. Distichals one to each ray division, all of them axillary; they are as large as the second costals, and give off from each of their sloping sides a single palmar, which supports two arms. Arm openings twenty, arranged in groups, those of the same ray equidistant, the spaces intervening between the rays twice as wide as those between their subdivisions, and that of the anal side about four times as wide. Arm structure unknown. First interbrachial large, generally as wide as high; it supports two somewhat smaller plates, which abut against the upper costals and the distichals, and these are followed by two still smaller pieces, which are on a level with the

arm bases. First anal plate longer than the radials, the median portions marked by a transverse ridge, followed by a longitudinal row of four additional anals, and these by a moderate number of irregular pieces which surround the anus. The four latter anals sustain at their sides a row of elongate plates, which decrease in size upwards. Anal area elevated, the median line forming a rounded ridge, which passes up to the posterior oral. Ventral disk inflated, as high as the dorsal cup, pentagonal in outline. The spines are long, sometimes reaching a length of 5 cm. or more; the other plates of the disk flat, or moderately convex. The posterior oral, which is represented by the central spine, is as large at its base as the other four orals together; the latter are pushed anteriorly. The first radial dome plates, which are represented by the five lateral spines are surrounded by five rather large plates, and these are followed downward by two secondary radial pieces and a large interambulacral. Anus on a level with the lateral spines, the opening directed laterally.

Horizon and Locality.—Upper part of the Keokuk group; Keokuk, Iowa, and Warsaw, Hamilton, and Nauvoo, Ills., also found at White's creek near Nashville, Tenn., and at several localities in Indiana and Kentucky.

Types in the Mineralogical Museum at Breslau, Germany.

Remarks.—Since the above description was written, we have examined a fine specimen in the collection of L. A. Cox of Keokuk, in which the arms are preserved to near their full length, and 13 cm. of the stem. The arms are paired and of moderate size; they are composed of rather long joints, which are not spine-bearing so far as observed. The column is rather heavy at the top, but tapers gradually from 8 mm. to 4 at the lower end. The first internodal joint exposed to view occurs between the eighth and ninth joints, but they increase rapidly in number, and soon attain the form and size of the nodal joints, which gradually become cylindrical and narrower.

***Dorycrinus Gouldi* (HALL).**

Plate XLIII. Figs. 2, 3, and Plate XLIV. Figs. 4, 5.

1858. *Actinocrinus Gouldi* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 613, Plate 15, Figs. 6a, b, c.

1873. *Dorycrinus Gouldi* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 380.

1881. *Dorycrinus Gouldi* — W. and SP.; Revision Palæocer., Part II., p. 179 (Proceed. Acad. Nat. Sci. Phila., p. 353).

Calyx about as high as wide, crowned by six extravagantly developed spines. Dorsal cup obpyramidal, obscurely pentangular to the top of the

costals, the arm regions distinctly lobed, the interradial spaces slightly flattened below and deeply depressed above. Plates formed into high nodes, which on the radials and brachials are transversely arranged and sharply angular, but on all interradial plates are circular and pointed.

Basal cup large, distinctly trilobate, three times as wide as high, the lower margins projecting, broadly notched along the sutures, the bottom deeply excavated for the reception of the column. Radials once and a half as wide as long, rapidly spreading to two thirds their height, the upper face concave. First costals half the size of the radials and quadrangular; the second generally heptangular, sometimes pentangular or hexangular, owing to the height of the first interbrachials. Distichals one, axillary, narrower than the costals, giving off from each side an elongate palmar; except in the antero-lateral rays, in which only the side of the costal toward the anterior ray bears an axillary, the other side two distichals, of which the second is twice as long as the first. The distichals and palmars have much the appearance of arm plates, being rounded exteriorly, so as to form a deep groove at each side. Arms arranged in groups, with wide and deep depressions between the rays. When normally developed, there are eighteen pairs: $\frac{3}{4}A$, but most of the specimens have a few single arms irregularly scattered between the paired ones. Arms thin and short, rounded on the back throughout their full length, their tips slightly tapering. First interbrachial large, generally longer than wide, its central part extended into a conspicuous node; the two of the second row about one half smaller; the plates of the third smaller still, followed by larger plates in the ventral disk. Anal interradius very wide, flat, and exceedingly deep at the arm regions; it consists of a longitudinal row of four large elongate anal plates, with smaller pieces above, forming a protuberance and enclosing the anal aperture. At each side of the second anal there is a large interbrachial, succeeded by several smaller ones on a level with the third anal. Ventral disk similar to that of *D. mississippiensis*, and the plates arranged in the same way; the spines, however, are somewhat longer, less tapering, and in the larger specimens are covered at intervals along the upper portions by small spiniferous nodes. The secondary radial dome plates, and the interambulacral between them, are somewhat smaller than in that species, and hence the height of the disk is a little less. Anal opening on a level with the lateral spines; facing laterally.

Horizon and Locality.—Middle part of the Keokuk group. Rare at

Keokuk, and generally crushed. Good calyces are found in Barren Co., Ky., and very excellent specimens with arms came from Indian creek, Montgomery Co., Ind.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — It is only in very large specimens that every arm is paired, single arms being most generally represented in one or more rays. It is also interesting to note that our largest specimen not only has the arms all in pairs, but has in both antero-lateral rays four pairs instead of three, — the only exception among seventeen specimens.

***Dorycrinus cornigerus* (HALL).**

Plate XLII. Figs. 5 and 6, and Plate XLIII. Fig. 5, and Plate XLIV. Figs. 6 and 7.

1858. *Actinocrinus cornigerus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 576, Plate 9, Figs. 12a, b, c, and ibid., Suppl., Plate 3, Fig. 4.

(Not *Actinocrinus cornigerus* LYON and CASS., 1859 = *Aorocrinus kentuckiensis*).

1873. *Dorycrinus cornigerus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 380.

1881. *Dorycrinus cornigerus* — W. and SP.; Revision Palæocr., Part II., p. 179 (Proceed. Acad. Nat. Sci. Phila., p. 353).

Syn. *Actinocrinus divaricatus* HALL; 1859, Suppl. Geol. Rep. Iowa, p. 11.

Syn. *Actinocrinus decornis* HALL; 1859, ibid., p. 13.

Calyx wider than high; the ventral disk as high as the dorsal cup. The latter turbinate, broadly truncated at the base, spreading rather rapidly from the top of the basals to the top of the costals, and thence more abruptly to the arm bases. The distichals and palmars form very prominent lobes with well defined sinuses between the arm-bearing plates. Plates smooth and almost flat, the suture lines but very slightly grooved.

Base large, the rim almost circular and without notches at the sutures; almost flat on the bottom, the column facet occupying but one fourth of its diameter. Form of radials variable; in some specimens almost as long as wide, in others nearly twice as wide as long, the upper face excavated. Costals rather large; the first quadrangular, once and a half as wide as long, the lower face convex; the second wider but not longer than the first; the sides spreading abruptly upwards; the three anterior ones generally heptangular, those facing the posterior side hexangular, the sloping upper sides straight, contrary to those of *D. quinquelobus*, in which they are excavated. The posterior rays, and occasionally the anterior one, have two axillary distichals, which on each side support a moderately long palmar, the latter ray in the

majority of specimens only to the right; while the antero-lateral rays have two successive distichals and no palmars. Distichals and palmars are distinctly rounded off at the sides, like free arm plates. Arm facets semi-ovate; the ambulacral openings directed slightly upwards, arranged in groups of four, two, and three (sometimes four in the anterior ray). The interspaces between the rays are wide, abruptly and deeply depressed, especially at the anal side, and those between the various ray divisions are deeply notched. Arms in pairs, two from each arm opening, long for the genus, incurving, flattened at the upper end, and every fourth plate giving off laterally from opposite sides sharp spines, 2 cm. in length. Interbranchials three, rather large, the two of the second row on a level with the arm bases. Anal area very wide, forming a low elongate ridge, grooved along the sides, which extends up to the posterior oral and contains the anus. First anal plate as long as wide, followed by two other anals of smaller size, the two latter sustaining an interbranchial at each side. Ventral disk hemispherical, with six long, slender, sharply pointed spines. The posterior oral, or plate bearing the middle spine, large and central, the other orals rather small and pushed anteriorly. The five radial spines are followed by two small secondary radial plates, and in rays with four arms by tertiary ones, which enclose an interdistichal. Anus opening out laterally, placed at midway between the posterior oral and the arm regions. Column very gradually sloping downward, with small cirri at the lower end, one to a joint, and at irregular intervals. The nodal joints of the upper portion of the stem are longer and considerably wider than those of the lower end; they project conspicuously over the internodal pieces, but gradually decrease in length and width, and at $5\frac{1}{2}$ cm. from the calyx have the same form and size as the others. The last two internodes in one of the specimens both contain seven joints.

Horizon and Locality. — Upper and Lower Burlington limestone, Burlington, Iowa.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — There can be no doubt that *Actinocrinus divaricatus* and *A. decornis*, both described by Hall, and afterwards placed by us under *Dorycrinus*, are mere variations of this species, as may be seen by comparing a large number of specimens. The former is a very mature form, in which the anterior ray obtained an additional pair of arms; in the latter, which came from the Lower Burlington bed, one or both posterior rays have but three arm openings, and, as a rule, the spines are shorter. The type

specimen of *Dorycrinus cornigerus*, figured in the Iowa Report, is somewhat misleading by having the arm-bearing plates broken. The calyx therein appears narrower than it naturally is, and gives no idea of the deep sinuses between the arm bases.

***Dorycrinus quinquelobus* (HALL).**

Plate XLII. Figs. 7, 8, 9.

1859. *Actinocrinus quinquelobus* — HALL; Suppl. Geol. Rep. Iowa, p. 15, and N. Y. State Mus. Nat. Hist., Plate 3A, Figs. 18, 19, and 20.
 1873. *Dorycrinus quinquelobus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 380.
 1881. Syn. of *Dorycrinus cornigerus* HALL — W. and SP.; Revision Palæocr., Part II., p. 179 (Proceed. Acad. Nat. Sci. Phila., p. 353).

A little larger than the preceding species and more robust; the calyx somewhat higher, broader at the base; the sides less spreading and convex; basals produced downward instead of outward; costals comparatively larger; the plates, as a rule, more convex, and the suture lines more distinct. Dorsal cup pentalobate, as high as the ventral disk, constricted at the basi-radial sutures; the spaces between the rays abruptly, depressed, and forming deep and broad notches within the arm regions. Surface of plates smooth.

Basals large, broad, the margins of the plates overhanging the top of the column, and forming at the bottom a concavity, which is wider than the column. Radials once and a half as wide as long, the upper face the widest. First costals unusually large, almost two thirds the size of the radials, quadrangular; sides and upper faces convex. Second costals pentagonal, hexagonal, or heptagonal, considerably longer than the first, the upper sloping faces rather deeply excavated for the reception of the distichals. The posterior rays, and also the anterior one, have but one distichal in both divisions, which is short and axillary; its upper faces, like those of the costal axillaries, are excavated, supporting a single palmar, which is remarkable for its great length, being fully twice as long as wide. The antero-lateral rays in which there are no palmars have two distichals, of which the first is very short, the second as long as the palmars of the other rays. The great length of the arm-bearing plates is one of the best characters of this species; they bend abruptly outward, are rounded on the back, and are separated from each other by deep notches. Arm openings arranged in groups of four, two, and four; directed slightly upward.

Arms in pairs, bifurcating on a minute axillary, which occupies the same face with the proximal arm plate; they are rounded and composed of rather short pieces, of which in the upper portions of the arms every third or fourth plate is extended laterally into a small node or short spine. Interbrachials three; the first twice as large as the others, higher than wide, and with concave sides; the two of the second row long and narrow. Anal area distinctly rounded, forming a low longitudinal ridge, with a deep groove at each side. The first anal plate is generally a little narrower than the radials, and followed by a vertical row of three or four higher anals, quadrangular in outline, which support a subcircular mammiloid protuberance containing the anus. Ventral disk highly convex, somewhat inflated; the posterior oral and the first radial dome plates extended into long, slender spines, the former central, and surrounded in mature specimens by about eleven convex pieces of nearly equal size, among which the smaller orals, if represented at all, cannot be identified. Similar pieces surround the radial spines, which enclose secondary radial plates. Anus at midway between the central spine and the arm regions; facing laterally. Column moderately small, composed near the calyx of narrow and wide pieces alternately arranged.

Horizon and Locality. — Upper part of the Upper Burlington limestone, Burlington and Pleasant Grove, Iowa.

Type in the (Worthen) Illinois State collection.

***Dorycrinus intermedius* (M. and W.).**

Plate XLIV. Fig. 1.

1868. *Dorycrinus quinquelobus*, var. *intermedius* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila. p. 346, and Geol. Rep. Illinois, Vol. V., p. 385, Plate 10, Fig. 4.

Intermediate between *Dorycrinus quinquelobus* and *D. mississippiensis*, differing from the former in its larger size, the more abrupt spreading of the dorsal cup, the different form of the basals, and the much greater length of its spines; from the latter in having invariably but two arm openings in the antero-lateral rays; and from both of them in the enormous size of its column.

Dorsal cup rapidly and uniformly spreading from the bottom of the radials to the arms; base broadly truncated, slightly projecting, and rounded at the lower margin; the interrarial spaces moderately depressed at the arm

regions, and not so deeply excavated as in some other species of this genus. Plates more or less tumid, their surfaces smooth; the suture lines quite distinct. Basals large, longer than in *D. mississippiensis*, but not overhanging the column so far as in *D. quinquelobus*; the sutures grooved. Radials once and a half as wide as long, rather deeply notched at the sides. First costals quadrangular, the sides convex; considerably wider than long. Second costals generally heptangular, sometimes hexangular; the sides rapidly spreading upwards; twice as wide as long. They support in the anterior and the two posterior rays an axillary distichal, and this from each side a moderately long palmar; the two antero-lateral rays have two rows of two distichals. Arm openings four, two, and four, directed outward. Arms in pairs, rather short, curving, flattened in the upper portions, and so far as seen, their sides without spines. Interbrachials three, the first twice as large as the two upper ones, the latter long and narrow, their upper ends rising to near a level with the bases of the arms. Posterior interradius as wide again as the others, with a low rounded median ridge and a depression at each side. The first anal, which is longer than the radials, is followed by three other anals, of which the lower one is the largest; all have an interbrachial at each side, those of the lower row being as large as the proximal plate in the other four interrarial spaces; the upper ones narrow, and resting within the depression at each side of the anal ridge. Ventral disk high, bulging, covered with six spines, of which the lateral ones in some specimens reach a length of 4 cm.; they curve downward, and taper gradually to a point. The median spine is straighter and somewhat shorter than the others. The anus occupies the middle part of a small, subcircular protuberance, composed of from six to eight pieces; it opens out laterally, and is placed on a level with the lateral spines. Column extremely large, fully twice as thick as that of *D. mississippiensis* although that is a larger species; nodal joints long, rounded at the edges, and one third wider than the intervening ones, which are quite short.

Horizon and Locality. — Transition bed between the Upper Burlington and the Keokuk beds.

Type in the Museum of Comparative Zoölogy.

Dorycrinus missouriensis* (SHUMARD).Plate XLIII. Fig. 6, and Plate XLV. Figs. 13a, b, c, and 14.*

1855. *Actinocrinus missouriensis* — SHUMARD; Geol. Surv. of Missouri by Swallow, Part II., p. 190, Plate A, Figs. 4a, b, c.
 1873. *Dorycrinus missouriensis* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 380.
 1881. *Dorycrinus missouriensis* — W. and SP.; Revision Palæoz., Part II., p. 179 (Proceed. Acad. Nat. Sci. Phila., p. 353).
 Syn. *Actinocrinus desideratus* HALL; 1861, Prelim. Descr. of New Palæoz. Foss., p. 2, and Boston Journ. of Nat. Hist., p. 353.
 Syn. *Dorycrinus desideratus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 380.

A variable species, remarkable for the extravagant development of its basal plates. Besides it differs from other species of this genus in the comparatively greater height of the dorsal cup, and the abrupt spreading of the distichals and palmars, which stand almost at right angles to the radials and costals. Calyx a little longer than wide; the ventral disk from one fifth to one fourth shorter than the dorsal cup. Plates thick, from almost flat to strongly nodose, the nodes upon the radials transverse and most conspicuous.

Base extremely large and heavy, spreading abruptly outward; its diameter in extreme cases equaling the width of the dorsal cup at the arm regions, and reaching a depth as much as 15mm.; interbasal sutures generally grooved and frequently notched. Radials about as long as wide; the sides nearly parallel; subquadrangular in outline; the sloping upper faces very short; the upper face concave. Costals very small, both together not more than half the size of the radials; their surfaces almost flat; the first quadrangular, twice as wide as long; the second one no longer but somewhat wider, and pentangular. The posterior rays have but one distichal, which is quite small and axillary, and gives off from each side a single palmar. The antero-lateral rays have two distichals, of which the second is twice as long as the first; the anterior ray generally has two distichals to the left and one to the right, followed by palmars; but this ray also occasionally has no palmars, and two distichals in both divisions. The arm-bearing plates, whether distichals or palmars, are twice as long as the preceding plate. The arms normally consist of fifteen pairs, arranged in groups of 4, 2, and 3, with wide and deep interspaces between the rays; they are short, rather stout for the genus, and bifurcate on a small trigonal axillary, which occupies the same facet with the proximal arm plates. Arm joints of medium size, and each fourth piece is produced

into a small lateral node. First regular interbrachials large, as wide as long, and tuberculous; followed by two smaller elongate, flat pieces which rest between the arm bases. Anal plates three, longitudinally arranged; the first as large as, or larger than, the radials; the two others somewhat smaller, supporting a subcircular mammillary protuberance, which is composed of comparatively few large plates, and is pierced by the anus. The posterior interradius has only two interbrachial plates, one to each side of the second anal. Ventral disk sub-hemispherical, covered with five long, slender spines. The posterior oral, which in other species is represented by a central spine, is here nodose, and three times as large as the others. In rays with four arm openings the spine-bearing plates are followed by two double rows of rather large alternate pieces; but in rays with two arms they are followed by two single rows, the single as well as the double rows enclosing a large subtrigonal interdistichal. Anus directed laterally, and placed at midway between the posterior oral and the arm regions. Column comparatively small, the facet for its reception deeply depressed, occupying in different specimens from one sixth to one tenth the diameter of the basal disk.

Horizon and Locality. — Upper Burlington limestone; Palmyra, Marian Co., Mo., and Burlington, Iowa.

***Dorycrinus Roemeri* MEEK and WORTHEN.**

Plate XLV. Figs. 15a, b.

1868. MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 346.

1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 383, Plate 10, Fig. 3.

1881. W. and Sp.; Revision Palæocr., Part II., p. 180.

Of the type of *D. missouriensis*. Calyx a little longer than wide, lobed at the arm bases, the dorsal cup obconical, nearly twice as high as the ventral disk, gradually spreading to the top of the costals, thence abruptly to the arms. Plates heavy, convex to nodose; the suture lines not grooved.

Basals somewhat expanding downward, truncated and moderately concave at the bottom, about twice as wide as high; the interbasal sutures slightly notched. Radials one third to one half wider than long, thickened in the middle into moderately prominent, rather obtuse, transverse nodes. Costals convex, quadrangular and pentangular; the first rather large, wider than long, the axillary a little wider in proportion. The latter supports upon its sloping upper faces in the anterior and both posterior rays an axil-

lary distichal, which in turn gives off two palmars, one to each side; while in the antero-lateral rays only the face toward the posterior rays bears an axillary, the opposite face two distichals, which are frequently anchylosed so as to form one large piece. The distichals and palmars are rounded off laterally, and resemble free arm plates. Arm openings directed horizontally, arranged in groups of 4, 3, and 4; the interspaces between the arms of the same ray narrow and slightly grooved, those between different rays much wider and deeply depressed. Structure of arms unknown. Regular interbrachials three; the first large, about as wide as high and tuberculous, the two others, which are on a level with the arm-bearing plates, small, elongate and flat. Posterior interradius very wide; it consists of a longitudinal row of three anal plates, of which each succeeding plate is one half larger than that below, and four interbrachials, two at each side of the anal series. The upper anal plate supports a very conspicuous oval protuberance, which extends prominently outward, and projects upward frequently beyond the central part of the disk, giving to the calyx an asymmetrical aspect. Ventral disk depressed hemispherical, crowned with five radial spines; the posterior oral, as in the preceding species, being merely convex or conical. The arrangement of the orals in this species is more symmetrical than usual in this genus, although the posterior one is not only larger than the others, but pushed in slightly between them. The spines, which are comparatively short, taper rapidly, and are succeeded toward the arms by two small secondary radial plates, and each of them by still smaller tertiary plates, which enclose a small interambulacral. The anus opens out laterally, and occupies the median part of the anal protuberance.

Horizon and Locality.—Upper part of Upper Burlington limestone; Burlington and Pleasant Grove, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks.—This species differs from *D. missouriensis* in the more conical form of the dorsal cup, in its much narrower base, in the extravagant development of its anal area, and in having an additional arm in all three anterior rays; all of which are constant characters.

Dorycrinus subturbinatus (M. and W.).*Plate XLII. Figs. 10a, b.*

1860. *Actinocrinus* (*Amphocrinus*) *subturbinatus* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 388.
 1866. *Amphocrinus subturbinatus* — M. and W.; Geol. Rep. Illinois, Vol. II., p. 212, Plate 15, Figs. 4a, b.
 1873. *Dorycrinus subturbinatus* — M. and W.; *ibid.*, Vol. V., p. 380.
 1881. *Dorycrinus subturbinatus* — W. and SP.; Revision Palæocr., Part II., p. 179.

A small species, in the form of the calyx resembling *D. mississippiensis*. Dorsal cup broadly obconical; the sides straight from the column to the arm bases, with a shallow depression at the interradial spaces; the rays not so distinctly lobed as usual in this genus; plates flat, and devoid of ornamentation or other markings.

Basals small, forming an obconical cup, rounded at the lower end; the column facet narrow, occupying the full width of the lower face. Radials a little wider than long, fully twice as wide as both costals together, the upper face concave. First costals quadrangular, as wide again as long. Second costals wider than the first, generally quadrangular, exceptionally hexangular or heptangular. They support in the anterior and posterior rays an axillary distichal, and this, in turn, a small palmar from each side; while the antero-lateral rays have two distichals and no palmars. Interbrachials one and two; the first large, as wide as long, the two others as long but one half narrower. Anal side very wide, a little bulging at the arm regions, incurving above, and elevated at the median line. It consists of three hexagonal anal plates, the first as large as the radials but somewhat longer and narrower; the other two decrease in size upward, and are followed by a number of smaller plates arranged around the anus. The anals from the second plate up sustain at each side an interbrachial, the lower pair of which being nearly as large as the corresponding single plate of the regular sides, the upper ones being much smaller. Ventral disk depressed-convex, somewhat inflated along the sides, flattened on top. The surface is covered with six spines, which are short, coming rapidly to a point. The middle spine occupies nearly the centre of the upper face, the lateral ones are placed almost vertically to the arm bases. Arrangement of orals and radial plates as in the preceding species. Anus at midway between the posterior oral and the base of the arms, directed laterally.

Horizon and Locality. — In the lower part of the Upper Burlington limestone, not found above the white crystalline bed, Burlington, Iowa.

Type in the Illinois State collection, Springfield.

***Dorycrinus unispinus* (HALL).**

Plate XLV., Fig. 12.

1861. *Actinocrinus unispinus* — HALL; Prelim. Desc. New Crinoids, p. 2, and Bost. Journ. Nat. Hist. p. 270.
 1873. *Dorycrinus unispinus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 380.
 1881. *Dorycrinus unispinus* — W. and SP.; Revision Palæocr., Part II., p. 180.
 Syn. *Actinocrinus trinodus* HALL; 1858, Geol. Rep. Iowa, Vol. I., Part II., p. 575.

Calyx moderately spreading to the top of the second costals, and thence more abruptly to the arms; it is distinctly truncated at the base, and, as seen from above or below, somewhat pentalobate at the arm regions. Ventral disk depressed convex, one fourth to one third shorter than the dorsal cup, and crowned by a single large spine. The plates of both hemispheres are not ornamented; they are virtually flat, with only the apparent convexity due to the slight grooving of the suture lines.

Basals forming a short cup, subcylindrical in outline, often slightly spreading to the lower margin, excavated at the bottom enough to enclose the two proximal stem joints, and pierced by a small pentangular canal. Radials a little wider than long, as large as the two costals together, the upper face concave. First costals quadrangular, nearly twice as wide as long, upper and lower faces convex. Second costals a little wider and longer. Number of arms exceedingly variable, with consequent variation in the distribution of the distichals and the presence or absence of palmars. The anterior and two posterior rays have either three or four pairs of arms; in the latter case there is but one distichal in both divisions, succeeded by 2×2 palmars, but if there are three pairs, the two divisions next the anal interradius have no palmars. The two antero-lateral rays rarely have more than two pairs of arms, and 2×2 distichals. Arm openings directed outward, arranged in groups; those of the same ray separated from those of adjoining rays by a deep depression. Arms incurving, rather stout for the genus, flattened in their upper parts and serrated at the edges, but without increasing materially in width. Regular interbrachials three, rarely four, the upper row on a level with the arm bases. Posterior interradius wider, formed at the upper end into a longitudinal ridge with a deep groove at

each side, reaching up to the posterior oral. It is composed of a series of four to five anal plates, longitudinally arranged; the first larger than the radials; the second interposed between two interbrachials; the third occupying the arm regions; the upper one followed by numerous irregular, small pieces, forming a tumor-like inflation which is pierced by the anus. Posterior oral central and drawn out into a long, sharp spine, which sometimes exceeds in length the height of the calyx. The other orals are somewhat tumid, as also the primary radial dome plates; while the interambulacral plates are almost flat. Anus placed at half way between the arm bases and the posterior oral, opening out laterally.

Horizon and Locality.—Lower Burlington limestone; Burlington, Iowa (a rare species).

Type in the University Museum at Ann Arbor.

Remarks.—“*Actinocrinus*” *trinodus* Hall is an abnormal form of this species, the radial dome plates of the two posterior rays, as in the case of “*Actinocrinus*” *tricornis*, are produced into spines. In the Revision, Part II., we erroneously placed this form under “*Dorycrinus*” *symmetricus*.

***Dorycrinus unicornis* (O. and SHUM.).**

Plate XLV. Figs. 8a-e, 9, 10.

1850. *Actinocrinus unicornis*—OWEN and SHUMARD; Journ. Acad. Nat. Sci. Phila., Vol. II. (new ser.), p. 67, Plate 7, Fig. 12; 1852, U. S. Geol. Surv. Wisc., Iowa and Minn., p. 593, Plate 5A, Figs. 12a, b.
1858. *Actinocrinus unicornis*—HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 568, Plate 10, Figs. 5a, b, c.
1873. *Dorycrinus unicornis*—MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 380, Plate 6, Figs. 2a, b, c.
1881. *Dorycrinus unicornis*—W. and SP.; Revision Palæocr., Part II., p. 180.
1890. *Dorycrinus unicornis*—S. A. MILLER; North Amer. Geol. and Palæont., p. 241, Fig. 294.
 Syn. *Actinocrinus tricornis*—HALL; 1858, Geol. Rep. Iowa, Vol. I., Part II., p. 569.
 Syn. *Dorycrinus tricornis*—WHITFIELD, 1893, Mem. Am. Mus. Nat. Hist. New York, p. 19, Plate II., Figs. 6 to 8.
 Syn. *Actinocrinus pendens*—HALL; 1860, Suppl. Geol. Rep. Iowa, p. 31.
 Syn. *Dorycrinus pendens*—WHITFIELD; 1893, Mem. Am. Mus. Nat. Hist. N. York, p. 18, Plate 2, Fig. 8.
 Syn. *Dorycrinus lineatus* S. A. MILLER; 1881, Journ. Cincin. Soc. Nat. Hist. (December), Plate 7, Figs. 3, 3a.
 Syn. *Dorycrinus inflatus* ROWLEY and HARE; 1891, Kansas City Scient., p. 114, Plate 3, Fig. 4.

Calyx spheroidal, broadly truncate at the lower end, moderately spreading to the top of the costals, thence abruptly to the base of the arms. Ventral disk almost as high as the dorsal cup, inflated at the posterior side, and crowned by a long central spine. Plates of the dorsal cup highly elevated;

those of the radial series formed into conspicuous, angular, transverse nodes, the interrarial plates into large rounded or pointed tubercles.

Base small, short, hexangular in outline, slightly notched at the suture lines, excavated at the bottom to enclose one or two joints of the column. Radials a little wider than long, the length of the lateral margins about equal to the width of the upper and lower faces; the upper sloping faces small. The nodes of the plates directed obliquely downward, and their extremities reaching the level of the lower face of the basals. First costals short, quadrangular, more than twice as wide as long. Second costals a little longer, pentangular or subtriangular, their lateral faces short. Distichals larger than the costals, there being two in the three anterior rays, which directly support the arms. In both posterior rays, the division facing the anal interradius has but one distichal, followed by two series of two palmars; while the other division has two distichals and no palmars. Arm bases projecting, indented at the sides, the interspaces between the rays wider than between their subdivisions, and the space between the posterior rays still wider. Arm facets large and lunate, the ambulacral openings facing outward. Arms in twelve pairs, long, stout, infolding, rounded at their bases, flattened and wider in the upper portions, and composed of two series of moderately short pieces, which grow longer upward. Some of these pieces are produced at the outer side into small nodes, which higher up in the arms turn into short, quite conspicuous spines. Near the calyx only every third plate bears a node, but throughout the flattened portions of the arms every other plate. Interbranchials three; the two upper ones elongate, resting between the arm regions. The plates of the posterior interradius consist of five or six large anal plates longitudinally arranged, of which the two upper take part in the ventral disk; and two interbranchials, one at each side of the second anal. The upper anal plate supports a number of small, irregular pieces, forming together a turgid elongate area, which near its upper extremity contains the anal opening. Plates of the ventral disk highly convex, sometimes conical, covered in well preserved specimens by small vermicular granules, except those surrounding the anus, which are perfectly smooth and almost flat. Orals large; the posterior one central, and extended into a long, slender spine. The food grooves are covered by three large plates of a first and second order, of which sometimes the primary plate in one or both posterior rays is spinous, while in most specimens these plates are no more tumid than the three others. Approaching the arm openings there are two secondary radial plates, which

enclose a large interdistichal. Column composed of large and small joints, the larger or nodal joints increasing in width downward, and at 4 cm. from the calyx are twice as wide as the intervening pieces; they are also much longer and angular at their outer edges.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa, Sedalia, Mo., and Lake Valley, New Mexico. This is one of the most characteristic species of the lower Burlington division.

Remarks. — *Actinocrinus tricornis* and *A. pendens*, both described by Hall, are undoubtedly specifically identical with *Dorycrinus unicornis*. In the first the posterior radial dome plates are extended into spines; in the second the nodes of the radials and first anal plate are "elongate and subclavate, being contracted in the middle, and swelling out at the extremities." Among this variety also we find specimens with one, two, or three spines upon the ventral disk, which are comparatively longer in young specimens. In the specimens from Pike Co., Mo., described by Rowley and Hare as *Dorycrinus inflatus*, the plates of the dorsal cup are less angular than usual in this genus.

AOROCRINUS W. and SP. (nov. gen.).

(*Ἄωρος* immature, *κρίνον* a lily.)

The species small. Form of the calyx and arrangement of the plates similar to *Dorycrinus*. As in that genus, the arms are arranged in groups, and vary in number among the rays, the anterior ray generally having the fewest. The arms are stout and packed closely together, there being invariably but one arm from each ambulacral opening in the calyx. The ventral disk, as a rule, is shorter than the dorsal cup, the plates are smooth or slightly convex, except the posterior oral, which is more or less elevated and frequently tuberculiform, but not actually spinous. The ambulacra are tegminal, and covered with two rows of small pieces. The anal area is composed of small plates, generally forming a protuberance or low ridge, which slopes downward almost in a straight line from the edges of the posterior oral to the first anal plate. The anus is placed near the upper end, and faces laterally.

Distribution. — This genus occurs in America in the Hamilton, Kinderhook, and in both divisions of the Burlington group. It survived to the Keokuk group, where it is represented by only a single species. In Europe it is possibly represented by "*Actinocrinus*" *prumiensis* Müller, from the De-

vonian of the Eifel, and there is another species at Colle, Spain, at a horizon which is generally recognized as Upper Devonian.

Type of the genus: Aorocrinus immaturus W. and Sp.

Remarks. — The species for which we propose the genus were referred heretofore by us and others to *Dorycrinus*, except *Aorocrinus Cussedayi* which had been placed under *Gemmæocrinus*. It approaches *Dorycrinus*, differing from it, however, in having single arms, and in not having the long spines upon which Roemer principally formulated his genus.

Aorocrinus precedes *Dorycrinus* in time, and has essentially the characteristics of an immature *Dorycrinus*. The peculiarities of that genus are foreshadowed, but have not acquired their full development.

***Aorocrinus immaturus* W. and Sp.**

Plate XLV. Figs. 4a, b.

1890. *Dorycrinus immaturus* — W. and Sp.; Geol. Rep. Illinois, Vol. VIII., p. 175, Plate 16, Fig. 5, and Plate 17, Figs. 6 and 17.

1890. *Dorycrinus immaturus* — S. A. MILLER; N. Amer. Geol. and Palæont., p. 240, Fig. 290.

Below medium size; crown measuring from 30 to 40 mm.; height of calyx from 10 to 14, by 10 to 12 wide. Dorsal cup higher than the ventral disk, gradually spreading to the arm bases, the sides a little convex. Tegmen depressed conical, crowned with a subcentral elongate node or short spine. Plates of the dorsal cup moderately convex, their surface more or less rugose, the suture lines distinctly grooved. Color of specimens rather dark.

Basals short, somewhat projecting beyond the column, their lower ends bending abruptly inward and forming a well defined concavity. Radials large, almost as wide as long, the lower margin but slightly convex, the upper face concave in the middle and truncated at the outer sides. Costals very short, and not much more than half the width of the radials; the first quadrangular; the second pentangular. Distichals 2×2 , in form resembling the radials, but only half their size. In some specimens all the second distichals are axillary and support palmars, in others those of the anterior ray support the arms, which vary in number from eighteen to twenty. Arms stout, single, biserial, and arranged in groups, the tips incurving and flattened; the interspaces between the rays deeper than those between their subdivisions, and in the anal interradius nearly three

times as wide. Interbranchials three; the first very large, as wide as high, the two upper quite small. They are followed by two still smaller pieces, which are on a level with the arm bases, and these by equally small interambulacral plates; there being no interdistichals in the dorsal cup, but several in the tegmen between the ambulacra. First anal plate much longer than the radials, and the largest plate of the dorsal cup. It is followed by three or four higher anals, longitudinally arranged, which decrease rapidly in size upward, each one having an interbranchial at the sides. There are numerous plates above, which form a longitudinal ridge with a deep sulcus at each side. The anus, which is placed at the upper end of this ridge, opens out laterally. Orals a little more convex than any of the other plates of the tegmen; the posterior one very large, its size equal to that of two of the others, and generally extended into a short spine. Food grooves covered by a few alternately arranged medium-sized plates, which are more prominent than the interambulacrals, especially on approaching the arms. Column comparatively short, gradually tapering, and terminating as a fine thread; its whole length being from 7 to 9 cm. The joints throughout are moderately long, and increase in length downward. They are in the upper part of the stem distinctly rounded at their margins, and project conspicuously over the younger joints; but at the lower part cylindrical and of equal width, giving off toward the end at irregular intervals, and at different sides, rather stout and long cirri.

Horizon and Locality.—Kinderhook group; Le Grand, Marshall Co., Iowa.

Types in the collection of Wachsmuth and Springer.

***Aorocrinus radiatus* W. and Sp.**

Plate XLV. Fig. 1.

1890. *Dorycrinus radiatus*—W. and Sp.; Geol. Rep. Illinois, Vol. VIII., p. 176, Plate 17, Figs. 5, 5a.
 1890. *Dorycrinus radiatus* S. A. MILLER; N. Amer. Geol. and Palæont., p. 240.

Resembling the preceding species, but having a different arm formula, and radiating ridges upon the plates. From the radials two low, rounded ridges pass out to the basals, two to adjoining radials and the first anal plate, and one to the first interbranchials. The latter plates have nine ridges, two meeting with those from the radials, the others, which are somewhat smaller, with the costals and the interbranchials of the second range. The ridges are well

defined next to the margin of the plates, but are indistinct, or disappear altogether, in the middle portions. Color of specimens lighter than in the last species. The calyx up to the arm regions is obconical, wider than high, and a little convex at the sides.

Basal cup short, projecting laterally, and forming a rim which is slightly excavated at the bottom. Radials somewhat shorter than those of *Aorocrinus immaturus*, the costals proportionally longer. The distichals vary in number; in the anterior ray there are 2×2 in the calyx, followed by free arm plates; the other rays have two in one division, but only one in the other, which is axillary and followed by palmars; exceptionally in the posterior rays the first is axillary in both divisions, but generally only that next to the anal side. Arms fourteen, rather stout, rounded on the back, and quite long; they are composed of two or three cuneate plates, which interlock and are followed by two series of transverse pieces, united by parallel sutures. Interbrachials six in three ranges; the first plate is large and extends to the top of the costals. There are three much smaller plates in the second range, and two in the third, the latter on a level with the arms. Anal area very wide, the first plate as large as the radials, the three succeeding plates fully equal in size to the single plate at the four regular sides, the middle plate being a little the largest. These plates are followed by numerous smaller ones, which take part in the ventral disk. Construction of the tegmen and position of the anus unknown. Of the column nearly three inches are preserved in one of the specimens; it is decidedly tapering, the nodal joints high and projecting. So far as observed, the stem changes but little its general habitus. As it decreases downward in width, the internodal joints retain nearly the same proportions to the adjoining nodal ones as close to the calyx.

Horizon and Locality. — Same as last.

Types in the collection of Wachsmuth and Springer.

***Aorocrinus parvibasis* W. and Sp.**

Plate XLV. Figs. 3a, b.

1890. *Dorycrinus parvibasis* — W. and Sp.; Geol. Rep. Illinois, Vol. VIII., p. 177, Plate 17, Figs. 7 and 9, 9a.

1890. *Dorycrinus parvibasis* — S. A. MILLER; N. Amer. Geol. and Palæont., p. 240.

A small species. Calyx oblate-spheroidal, excavated at the bottom. Dorsal cup in form of a basin that rests upon the basals and portions of

the radials; wider than high, and spreading but little at the sides. Plates moderately convex, without ornamentation; suture lines well defined, with a small pit at each angle of the plates. Color of specimens as in *A. immaturus*.

Basals forming a disk, which rests within a shallow concavity formed by the united radials, and not visible in a side view. Radials large, heptagonal, narrow below and wide above, the lower end curving inward. Costals small, nearly of equal size. Distichals unevenly distributed among the rays, the three anterior rays having from two to three in the calyx, which are followed by free arm plates; the two posterior rays, in the division next to the anal side, but one, which is axillary and followed by two fixed palmars; the opposite side having three distichals, thus making fourteen arms to the species. Arms arranged in groups, the space between the posterior rays much the widest; they are quite robust, tapering at the end, rounded, and biserial except one or two cuneate pieces at the base. Interbranchials in two ranges; the first very large, reaching the top of the costals, and touching the distichals, the others small, resting between the distichals. A third range is on a level with the arm bases, and followed in four of the areas by four to five interambulacrals. Anal area very wide, elevated along the median line, deeply grooved at each side, so as to form from the distichals to the posterior oral a longitudinal ridge, which is most prominent in the upper part around the anus. First anal plate larger than the radials, longer than wide; the second, and the interbranchials at the sides, as large as the corresponding single plate of the other areas; the plates above small and irregular in their arrangement. Tegmen depressed convex. Orals large; the posterior one extended into a thick, elongate node, and twice as large as the others, which are moderately convex. Anal opening directed laterally. The food grooves and their branches, respectively, are covered by a single plate. The stem apparently was longer than in the two preceding species, and less tapering. The nodal joints are a little wider than the intervening ones, which increase very rapidly in number, there being six to the internode at an inch from the calyx, which appears to be the maximum number.

Horizon and Locality. — Same as last.

Types in the collection of Wachsmuth and Springer.

Aorocrinus canaliculatus (M. and W.).*Plate XLV. Figs. 6a, b.*

1869. *Dorycrinus canaliculatus* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 166.

1873. *Dorycrinus canaliculatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 381, Plate 6, Fig. 4.

1881. *Dorycrinus canaliculatus* — W. and SP.; Revision Palæocr., Part II., p. 179 (Proceed. Acad. Nat. Sci. Phila., p. 353).

Calyx below medium size, its height a little less than the width at the arm bases, the dorsal cup shorter than the ventral disk; the former with broadly truncated bottom and moderately spreading sides; the latter depressed conical. Plates of the dorsal cup convex, roughened by a peculiar shallow pitting, which extends over the entire surface, but is more conspicuous around the margins of the larger plates, to which it imparts a slightly crenate appearance; suture lines deeply canaliculated. The plates of the ventral disk are less convex, but also defined by canaliculated sutures, and roughened by a pitting like that in the dorsal cup.

Basals extremely small; only their outer angles visible in a side view; subhexagonal in outline, with small lateral notches at the sutures; the column facet occupying two thirds the depth of the plates. Radials once and a half as wide as long, the extreme lower end bending inward to meet the basals. First costals quadrangular, fully one half smaller than the radials, and about once and a half as wide as long; the second quadrangular and somewhat wider and longer. Distichals 2×2 , as wide as the first costals but still shorter. In the posterior rays both upper distichals are axillary, and each one supports two palmars; in the anterior ray only the one to the right is axillary, the other bears a single arm; the antero-lateral rays have no palmars in either division, and but two arms. Arm openings arranged in groups with rather wide interspaces, of which that at the anal side is almost three times as wide as the others. Arms sixteen, one from each opening; rather heavy and long, incurving, their upper ends flattened and distinctly serrated at the outer edges. Pinnules closely packed together; their joints but little longer than wide. First interbrachial almost as large as the radials; it is followed by two plates in the second, and two in the third range, the latter on a level with the arm bases, and in contact with the interambulacral pieces. The first anal plate supports three additional anals in a longitudinal row, which rapidly decrease in size upward, and each one of them is

placed between the two interbrachials. The plates of the ventral disk are rather small, the posterior oral excepted, which is quite large, tuberculiform, and central in position. The anus is placed a little above the arm regions; it is surrounded by numerous small plates, and opens out laterally. The ambulacra apparently are roofed by small covering pieces.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

***Aorocrinus subaculeatus* (HALL).**

Plate XLV. Figs. 7a, b.

1858. *Actinocrinus subaculeatus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 570, Plate 10, Figs. 2a, b.

1873. *Dorycrinus subaculeatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 380.

1881. *Dorycrinus subaculeatus* — W. and SP.; Revision Palæocer., Part II., p. 180 (Proceed. Acad. Nat. Sci. Phila., p. 354).

A small and very rare species. Dorsal cup symmetrically semiglobose; the tegmen abruptly conical, with an acute spiniform plate at the top. Plates delicate, flat (their natural curvature excepted) and perfectly smooth; the suture lines obscure.

Basals in form of an inverted cup, very small, and frequently not visible in a side view. Radials almost as long as wide at the upper end, the lower end considerably narrower and bending inward. Both costals together equal to the size of the radials; the first quadrangular, fully twice as wide as long; the second pentangular and wider as well as longer. Distichals 1×2 ; those of the posterior rays axillary, and followed by two single very small palmars. In the antero-lateral rays only that next to the posterior ray is axillary, the other subquadrangular; the former supporting two small palmars and two arms, the latter a single arm. The same structure prevails in the anterior ray, in which the distichal to the right supports the two arms. The arm-bearing plates somewhat projecting. Arm openings directed laterally, arranged in groups, the spaces between the rays depressed, that of the anal side deeper and wider. Arms fifteen; their structure not known. The first anal plate is longer than the radials and fully as wide; it supports three large plates in the first range, and three much smaller ones in the second. The plates above are small and irregularly arranged, forming a flattened area, which extends to the posterior oral. The interbrachials of the other areas consist of three plates in the dorsal cup, and two between the arms, which latter insensibly connect with the interdistichals. The anus is placed half

way between the large oral and the arm regions, and opens out laterally. Structure of arms and column not known.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — Closely approaching *Aorocrinus parvibasis*, which has a similar base, and resembles it in its general outline; that species, however, has a very different arm formula, and the plates of the calyx are distinctly convex.

***Aorocrinus parvus* (SHUM.).**

Plate XLV. Figs. 11a, b.

1855. *Actinocrinus parvus* — SHUMARD; Rep. Geol. Surv. Missouri by Swallow, Part II., p. 193, Plate A, Fig. 9.

1881. *Dorycrinus parvus* — W. and Sp.; Revision Palæocr., Part II., p. 179 (Proceed. Acad. Nat. Sci. Phila., p. 353).

Syn. *Actinocrinus symmetricus* — HALL, 1858, Geol. Rep. Iowa, Vol. I., Part II., p. 574, Plate 10, Figs. 8a, b.

Syn. *Dorycrinus amœnus* — S. A. MILLER; 1891, Geol. Surv. Missouri by Arthur Winslow, Bull. I., p. 35, Plate 4, Figs. 5 and 6.

A small species. Calyx rotund; the dorsal cup higher than the ventral disk, slightly obconical; the peripheral portions abruptly projecting outward, and distinctly lobed; the interspaces between the rays broadly and deeply excavated, and there are smaller excavations between their main divisions. Plates flat and without markings, except an obscure longitudinal ridge upon the costals and distichals.

Basals rather large, forming a broad, shallow cup with a narrow excavation at the bottom. Radials very large, almost as long as wide; the truncated upper faces as wide as the upper face. First costals quadrangular, once and a half as wide as long, the second quadrangular, smaller than the first. Distichals one or two. All divisions in which palmars are represented have but one distichal, but those in which they are wanting have two. The anterior ray invariably has but two arms, the two posterior ones from three to four, and the antero-lateral rays from two to four, frequently the left having more than the right, or *vice versa*. The number of fixed palmars varies from one to two, and large specimens generally have a small interdistichal. Arm openings directed slightly upwards, and arranged in groups of two or one. Arms one from each ambulacral opening in the calyx; they are short, heavy, biserial; their plates moderately short, and every fourth piece extended into a well defined lateral spine. Interbrachials five to seven:

1, 2, 2, 2; the two upper on a level with the arm bases. Posterior area extremely wide, its median line rounded but not ridged. First anal plate followed by three large plates, and these by three smaller ones, which support numerous others without definite arrangement. The plates of the tegmen are flat, except the posterior oral, which is slightly convex and central in position; the four other orals are pushed anteriorly, and are surrounded in large specimens by irregular perisomic plates. In smaller specimens, their outer edges abut against a large radial dome plate, from which two rows of covering pieces at both sides pass out to the arms. The anus is placed half way between the summit and the arm bases, and opens out laterally. Column small; composed near the calyx of wide and narrow joints.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa, and at the same horizon at several localities in Missouri and Illinois.

Remarks. — The arm formula of this species varies exceedingly. Among seventeen specimens there is one with $\frac{4-4}{2}$ arms, five with $\frac{3-3}{2}$ arms (this is the arm formula of "*Actinocrinus*" *symmetricus* Hall), six with $\frac{2-2}{2}$ (as in S. A. Miller's *Dorycrinus amoenus*), one with $\frac{3-2}{2}$, and four with $\frac{2-2}{2}$ arms. As a rule, large specimens have more arms than smaller ones, and the specimens with ten arms are without exception small. The specimens are identical otherwise, and this proves most conclusively that the number of arms, in this group at least, cannot be made a specific character unless accompanied by other structural differences. Such, however, do not exist in *Dorycrinus amoenus* Miller, nor in *Actinocrinus symmetricus* Hall.

***Aorocrinus spinosulus* (Hall).**

Plate XLIII. Fig. 4, and Plate XLIV. Figs. 8a, b.

1859. *Actinocrinus spinosulus* — HALL; Suppl. Geol. Rep. Iowa, p. 52.

1881. *Dorycrinus spinosulus* — W. and SP.; Revision Palæocr. Part II., p. 180.

Syn. *Dorycrinus Kelloggi* — WORTHEN; Geol. Rep. Illinois, Vol. VI., p. 513, Plate 29, Fig. 8.

A small species. Dorsal cup obconical, strongly lobed at the arm regions, truncated at the base; ventral disk almost flat and without spines. Plates devoid of ornamentation, a little convex, the suture lines grooved.

Basals large, forming a cylindrical cup, excavated at the bottom. Radials very large, longer than wide, the sloping upper faces short. First costals hexangular, of more than medium size, one third wider than long. Second

costals pentagonal, a little larger than the first, their sloping upper faces in all the rays supporting an axillary distichal, and this two small palmars, which among themselves, and with the two of the opposite side of the ray, are in contact laterally. Arm openings small, four to the ray; arms simple, very short and delicate. Interradial spaces wide and deeply depressed between the free rays. Regular interbranchials 1, 2, 3, decreasing in size upward; the first not larger than the first costals; the two of the second row somewhat smaller; those of the third narrow, occupying the depressions between the rays. The interbranchials are followed by three or four minute interambulacral pieces which meet the orals. Anal interradius extremely wide, the interspace at the arm bases twice that of the other rays. There is a vertical row of four anal plates, followed by a number of irregular pieces, which form an almost flat area and enclose the anal opening. At each side of the second anal plate there is a good sized interbranchial, and to each side of the second are two smaller pieces. Orals large, occupying fully one half the surface of the disk; they are convex, sometimes conical but not spinous; the posterior one is a little larger than the four others and pushed in between them, but, as a rule, the orals of this species are more symmetrically arranged and proportionally larger than usual in this genus. The primary radial dome plates resemble the orals in form and size, and occupy the outer end of the lobes. Anal opening directed laterally, and placed almost on a level with the arm bases.

Horizon and Locality. — Keokuk group, Keokuk, Iowa, and Nauvoo, Ills.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — We regard *Dorycrinus Kelloggi* Worthen as identical with this species, from which it was said to differ in the number of arms. That species was described as having but three arms in one of the antero-lateral rays, a structure which clearly indicates an irregular development of the rays.

Aorocrinus spinosulus is closely related to *A. parvus* Shum. from the Burlington group, and its structure indicates that it is a descendant of that species, but sufficiently differentiated to be ranked as a good variety, if not as a full species.

Aorocrinus elegans (S. A. MILLER).*Plate XXXIV. Figs. 17a, b.*

1892. *Dorycrinus elegans*—S. A. MILLER; Adv. Sheets 18th Rep. Geol. Surv. Indiana, p. 17, Plate 3, Figs. 4 and 5.

A moderately small species, calyx obconoidal, as wide as high, the base truncated, the sides almost straight, and not grooved between the rays, except the anal side which has a depression at the arm regions. The plates slightly convex but without ornamentation; the suture lines somewhat channeled.

Basal cup rather high, subcylindrical, the interbasal sutures slightly notched at the bottom; the column facet deeply depressed, and occupying half the diameter of the cup at the lower end. Radials a little spreading, larger than both costals together, and generally as long as wide, their lateral faces longer than the upper. Costals small, variable in form and size, some of them quite narrow and almost as long as wide, others almost twice as wide as long; the first quadrangular, the second pentangular, hexangular or heptangular, owing to the height of the adjoining first interbrachial. Distichals two, as large as the costals and of similar form. Palmars but one row in the calyx. Arms four to the ray; their structure not observed, but they evidently were simple, to judge from the arm openings. Regular interbrachials three; the first rather large, and about as high as wide; the two of the second row less than half the size of the first, and one of them generally a little larger than the other, both separated from the plates of the disk by the palmars, which meet above. Anal plate of the size of the radials; followed by three plates, which are almost as large as the first interbrachial of the regular sides. There are three smaller plates in the third row, and these are succeeded by a very large elongate plate, which forms the bottom of the depression at the arm regions. Ventral disk very slightly convex, almost flat, and composed of but few large plates. The orals decidedly asymmetrical in their arrangement, the two postero-lateral ones forming a straight line with the posterior one; they are very large and occupy almost one half of the disk. The ambulacra represented by one large plate, followed by two somewhat smaller ones of a secondary order. The interambulacral plates consist of only two very narrow, elongate pieces. Anus subcentral, in close proximity to the posterior oral, directed upwards, and placed in the centre of a short protuberance.

Horizon and Locality. — Upper Burlington limestone, near Sedalia, Mo.

Type in the collection of Mr. F. A. Sampson, Sedalia.

Remarks. — The obconical form of the cup, and the almost flat disk, are the leading characters of this species, in which it approaches *A. spinosulus* Hall. However, the calyx of that species is deeply grooved at all sides, and the rays are separated by numerous interbrachial plates which pass up to the plates of the disk.

***Aorocrinus helice* (Hall).**

Plate XLV. Figs. 2 and 5.

1864. *Actinocrinus helice* — Hall; 17th Rep. N. Y. State Cab. Nat. Hist., p. 53.

1878. *Actinocrinus helice* — Hall; Geol. Surv. Ohio, Palæont., Vol. II., p. 163, Plate 11, Figs. 5 to 8.

1881. *Agaricocrinus helice* — W. and Sp.; Revision Palæocr., Part II., p. 112 (Proceed. Acad. Nat. Sci. Phila. p. 286).

Syn. *Actinocrinus helice*, var. *eris* Hall; Geol. Surv. Ohio, Palæont., Vol. II., p. 164, Plate 11, Figs. 9 to 10.

Syn. *Agaricocrinus eris* — W. and Sp.; 1881, Revision Palæocr., Part II., p. 112.

Approaching in the form of the calyx, and the stoutness of its arms, some of the aberrant smaller forms of *Agaricocrinus*. Calyx wider than high, the summit crowned with an elongate node or short spine. Dorsal cup short, rapidly spreading to the arm bases, rounded at the bottom, the lower margins of the radials bending inward and taking part in the truncation at the bottom. Surface of plates nodose, the radial ones transversely angular, the interrarial ones with obscure radiating ridges along the margins.

Basals small, arranged almost horizontally; only small portions of them being exposed in a side view; the interbasal sutures deeply channeled at the lower end. Radials large, rapidly spreading upwards; the upper face slightly notched at the sides. First and second costals together smaller than the radials; the first quadrangular, the second pentangular. Distichals short, consisting in the anterior ray of three rows of plates in the calyx, of which those of the first row are somewhat larger than the two of the succeeding ones, the latter being as short as the free brachials above, and like them rounded on the back. In the posterior rays both first distichals are axillary, and support from each side two short fixed palmars. In the two antero-lateral rays normally the distichals next to the posterior rays are axillary and support palmars, the others are followed by other distichals; it occurs, however, also that none of them are axillary or both of them; the number of arms thus varying from twelve to sixteen. Arms rounded on

the back, very stout, widest at midway, somewhat tapering at both ends, the tips infolding. The free arm plates are elevated in the centre, and produced into transverse angular ridges, which in the upper part of the arm are broken into nodes. There is but a single interbrachial at the regular sides; the anal side has two, which enclose a second anal. The first anal is a little longer than the radials. The exact arrangement of the plates in the tegmen cannot be accurately ascertained from any of the specimens. Column comparatively strong; the nodal joints a little highest and widest, and rounded at their edges.

Horizon and Locality. — Waverly sandstone; Richfield, Summit Co., and Royalton, Cuyahoga Co., Ohio. (Fig. 2 is made after Hall, Fig. 5 drawn from a gutta percha cast made in a natural mould.)

***Aorocrinus concavus* (MEEK and WORTHEN).**

Plate XLII. Figs. 13a, b, c.

1861. *Actinocrinus (Amphocrinus) concavus* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 132.
 1865. *Actinocrinus (Sphaerocrinus) concavus* — M. and W.; *ibid.*, p. 154.
 1865. *Actinocrinus (Caelocrinus) concavus* — M. and W.; *ibid.*, p. 273.
 1866. *Caelocrinus concavus* — M. and W.; Geol. Rep. Illinois, Vol. II., p. 215, Plate 15, Figs. 10a, b, c.
 1881. *Dorycrinus concavus* — W. and Sp.; Revision Palæocr., Part II., p. 179 (Proceed. Acad. Nat. Sci. Phila., p. 353).

A small species. Calyx subglobose, wider than high; the ventral disk almost flat. The sides of the dorsal cup rise nearly vertically from the middle of the radials to the arm regions; the lower half curving abruptly inward, and forming with the basals the bottom of the cup. The plates are nearly flat and devoid of ornamentation.

Basals small, spreading almost horizontally, and forming a shallow inverted basin, which is slightly notched at the sutures. Radials extremely large, fully twice the size of both costals together. Costals very small, quadrangular and pentangular. Distichals 1×2 , supporting the arms, except in the posterior rays, in which the divisions next to the anal area support palmars, and there are three arms to the ray in place of two in the others. Arm openings small, directed outward; the structure of the arms not known. The interbrachials consist of one large plate and two smaller ones, the latter being on a level with the arm bases. First anal larger than the radials; followed by three rows of three plates each, which decrease in size upwards, and connect with the anal opening. Tegmen very short, a little depressed

at the anal side, and composed of but few, rather large pieces, among which the orals are well defined. The posterior oral is central, larger than the surrounding ones, and more convex. The anus opens out obliquely upwards.

Horizon and Locality.—Lower Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks.—This species is readily distinguished from allied forms by the concavity of the basals, the curvature and extremely large size of the radials, the vertical position of the fixed brachials, and the flatness of the tegmen. It was at first referred by Meek and Worthen to *Amphoracrinus*, but they afterwards regarded it as the type of a new genus, for which they proposed the name *Sphærocrinus*, which, being preoccupied by Roemer, was changed into *Cœlocrinus*.

***Aorocrinus Cassedayi* (LYON).**

Plate XLII. Figs. 11a, b, and 12.

1860. *Actinocrinus Cassedayi*—LYON; Proceed. Acad. Nat. Sci. Phila., p. 410, Plate 4, Figs 3, 3a.

1881. *Gennæocrinus Cassedayi*—W. and SP.; Revision Palæocr., Part II., p. 161.

(?) Syn. *Actinocrinus cauliculus*—HALL; 15th Rep. N. Y. State Cab. Nat. Hist., p. 132.

(?) Syn. *Actinocrinus calypso*—HALL; *ibid.*, p. 133.

Calyx small, width across the arm bases slightly exceeding the height, broad at the bottom, constricted at the basi-radial sutures; the interrarial spaces deeply indented at the arm regions, especially at the anal side, which gives to the distichals and palmars the appearance of arm plates. Plates of the dorsal cup strongly convex, the surface covered with radiating ridges, which enter only the margin of the plates.

Basals large, short, forming a broad rim with sharp marginal edges, which are notched at the sutures; the lower face a little concave, and the median part somewhat excavated for the reception of the column. Radials comparatively large, but smaller than the basals; wider than long. First costals about half the size of the radials; the second generally smaller than the first. Distichals 2×10 , the upper axillary and followed by two rows of palmars; the latter, as well as the distichals, curved like arm plates, and projecting conspicuously over the interrarial spaces. Arms twenty, four to each ray. Interbrachials four to six; two in the second row, two or three in the third, and two between the arms, the latter connecting with the interambulacral pieces. Anal interradius considerably wider; the first anal followed by three plates, all somewhat smaller than the first interbrachial of the other sides; and these by a large number of minute, irregular pieces, forming a rounded, almost

vertical ridge, which extends above the arm regions, enclosing the anal opening, which is directed laterally. Interdistichal spaces deeply grooved, and occupied by a single minute piece. Ventral disk low, slightly convex, pentangular in outline. The ambulacra are tegminal and raised above the general level of the disk; the food grooves covered by two rows of comparatively stout pieces with a large nodose plate above each bifurcation. Posterior oral proportionally large, extended into an elongate node; the four others barely convex. Column small; the axial canal minute.

Horizon and Locality.—Hamilton group; Louisville, Ky., Clark Co., Ind., and Alpina, Mich.

Types in the Knapp collection at New Providence, Ind.

Remarks.—From Hall's descriptions it seems to us probable that his *Actinocrinus cauliculus*, *A. præcursor*, *A. pocillum*, and *A. calypso*, from the Hamilton group of the State of New York, are all or in part identical with this species. As neither one of them is figured, and the types in the State Museum of Albany are not accessible to us, we are unable to make the necessary comparison. In 1881 we erroneously placed this species under *Gennæocrinus*. A subsequent comparison with the types shows clearly that it has essentially the characteristics of *Aorocrinus*.

BARRANDEOCRINUS ANGELIN.

Plate VIII. Fig. 1.

1878. ANGELIN; Iconogr. Crin. Suec., p. 7.

1885. W. and SP.; Revision Palæocr., Part III., p. 125.

The calyx in perfect specimens is invisible, being completely enveloped by the arms and pinnules, which hang down over it; and the specimens, when all the arms are in place, have a superficial resemblance to a Blastoid. The calyx is composed of comparatively few plates, and resembles *Dorycrinus* in the form of the dorsal cup, from which it differs essentially in the structure of tegmen and arms.

Basals three, large. Radials quite irregular in outline; the posterior ones pentangular, the anterior one hexagonal, and the remaining two heptagonal. Costals two, the axillary very small, subtriangular, its upper angle sharply pointed. Distichals apparently but one in the calyx. Arms ten, very heavy, biserial, folding outward and recumbent over the calyx, covering the latter completely, and leaving of the arms only the pinnules exposed

at the outer surface. The pinnules form a longitudinal roll along the sides of each arm; they are closely packed, and their ends infold over the food grooves from the sides. In the fossil state the dorsal surfaces of the pinnules are exposed to view, but in the living crinoid they evidently were capable of straightening out to expose their ventral surfaces, and to open the food grooves of the arms to the water. The pinnules are composed of very deep, elongate joints; they are contiguous at their proximal ends, and so regularly arranged that it appears as if they might have been connected laterally for a part of their length, only the upper parts being movable. Interbrachials one; large; followed by two smaller ones, which meet with the plates of the disk. The anal plate rests upon two basals; it is nine-sided, and succeeded by three and two plates. Of the construction of the tegmen very little is known, it being generally concealed by the lower pinnules; but from appearances it was composed of large, subspinous orals, asymmetrically arranged, which alternated with five similar plates evidently representing radial dome plates. Anus excentric, opening directly through the disk. Column stout, circular.

Distribution. — Restricted to the Upper Silurian, and hitherto recognized only in Gotland, Sweden.

Type of the genus: *Barrandeocrinus sceptrum* Angelin.

Remarks. — Through the kindness of Dr. G. Lindström and the great skill and intelligence of Mr. Liljevall, we were enabled to procure a series of drawings made from specimens in the National Museum at Stockholm, by means of which the details of structure of this extraordinary Crinoid are shown very completely. (Plate VIII., Fig 1.) Although superficially presenting unique characters, it is a true Batocrinoid, and we find no necessity of recognizing for this genus a distinct family. The recumbent arm feature is found among the Hexacrinidæ, and also in one species of the Acrocrinidæ, in which it is as marked a character as in *Barrandeocrinus*, but in *Acrocrinus* and the other forms with recumbent arms — except *Barrandeocrinus* — the pinnules are stretched out, and their ventral surfaces are exposed instead of being folded over the ventral surface of the arm.

Our generic description was made to agree with the Swedish form, and may have to be slightly modified should additional species be discovered hereafter. It is possible that the specimen figured and described by S. A. Miller in the 18th Report of the Indiana Geological Survey, p. 31, Plate 5, Figs. 13 and 14, under *Cylicocrinus canaliculatus* may belong to this genus.

We have not seen the type specimens, and neither Miller's figures nor his description enable us to make a satisfactory comparison. If it should prove to be the type of a new genus, the proposed name *Cylicocrinus* cannot be used for that form, as it was preoccupied in 1855 by Joh. Müller for a Devonian genus. Müller made the name "*Cylicocrinus*," which has the same derivation as *Cylicocrinus*.

AGARICOCRINUS (TROOST) HALL.

1850. TROOST; List. Crin. Tenn. (Proceed. Amer. Ass. Adv. Sci.), p. 60.
 1858. HALL (Subgenus of *Actinocrinus*); Geol. Rep. Iowa, Vol. I., Part II., p. 560.
 1861. HALL (Subgenus of *Amphoracrinus*); Boston Journ. Nat. Hist., Vol. VII., p. 280.
 1866. MEEK and WORTHEN (Subgenus of *Actinocrinus*); Geol. Rep. Illinois, Vol. II., p. 210.
 1873. MEEK and WORTHEN (Subgenus of *Amphoracrinus*); *ibid.*, Vol. V., p. 499.
 1879. ZITTEL (Subgenus of *Amphoracrinus*); Handb. der Paläont., Vol. I., p. 371.
 1881. W. and S.; Revision Palæocr., Part II., p. 109 (Proceed. Acad. Nat. Sci. Phila., p. 283).

Calyx conical or depressed globose; the lower face concave, flat or broadly convex. Basals three, small, arranged horizontally, and forming a hexagon, which is partly covered by the column. Radials rather small. First costals quadrangular, rarely hexangular; the second pentangular or hexangular according to the height of the interbrachials. Size of the second costals and first distichals extremely variable, sometimes the former being the largest plates of the calyx, and sometimes the latter. Arms two to four to the ray; the arm facets of the same ray contiguous, but each arm having a separate ambulacral opening; the arm bases of adjoining rays separated by interbrachials. The earlier species have two arms to the ray, but most of the later ones three—some of them four—in the posterior rays, and two in the others. When there are but two arms, the first distichals are followed by a moderately short, somewhat cuneate second plate, which bends inward like an arm plate, and this again by two rows of short, heavy arm plates, of which the proximal one, and frequently those of the two succeeding rows, are in contact with their fellows of adjoining arms. The arm plates interlock with those of the opposite row, and the inner ones with the proximal distichals, which are also alternately arranged among themselves. Arms long and ponderous, heaviest at their bases, whence they taper gradually to the tips. Interbrachials three or more; in size as variable as the costals and distichals, but all of them narrow and long. In some species the first plate rises almost to a level with the arm bases, in others only to the middle of the first costals, and in this case the two plates of the second range are

extremely long. First anal considerably longer than the radials, and much narrower at the upper end; it supports an elongate second anal, and at each side a large interbrachial; the succeeding plates are much smaller, and form a more or less protuberant area, which extends to the posterior oral, and contains the anus, which opens out laterally. Ventral disk conical or hemispherical, the interrachial spaces somewhat depressed. Oral plates large and prominent; the posterior one larger than the other four, and central, either in contact with the latter, or separated from them by small perisomic plates. The food grooves covered by superimposed interambulacra, and toward the margin of the tegmen by one or more large radial plates. Column long, composed of large and smaller pieces; the axial canal rather small and pentalobate.

Distribution. — Known only from the Mississippi Valley, where it occurs in both Burlington beds, and also in the Keokuk group.

Type of the genus: *Agaricocrinus americanus*.

Remarks. — This genus is most remarkable for the depression of the dorsal cup, of which in the typical form only the arm facets and portions of the interbrachials can be seen in a side view, the lower parts being flat or more or less concave. Another good character is furnished by the distichals, which, taking the form of arm plates, curve inward and interlock with one another; and last but not least, by the ponderous, gradually tapering, biserial arms, and the elongate form of the interbrachials. In all of these *Agaricocrinus* differs essentially from *Aorocrinus* and *Dorycrinus*, with which it has certain affinities. It has been most frequently confounded with *Amphorocrinus*, to which in some species it has a superficial resemblance in the form of the calyx; but the arm structure and position of the anus in the two genera are different, and, in the typical forms, *Amphorocrinus* has only two plates in the row above the anal plate. For specific separation we rely upon the variations in the proportions of the interbrachial plates, and the form and size of the costals and distichals, as the best distinctive characters. The number and distribution of the arms, the form of the anal area, and the condition of the oral plates, are also important.

Agaricocrinus Americanus (ROEMER).*Plate XLII. Figs. 1, 2a, b.*

1855. *Amphoracrinus americanus* — ROEMER; *Lethæa Geogn.* (Ausg. 3), p. 250, Plate IV., Figs. 15a, b.
 1865. *Agaricocrinus americanus* — SHUMARD; *Trans. Acad. Sci., St. Louis*, Vol. II., p. 351.
 1881. *Agaricocrinus americanus* — W. and SP.; *Revision Palæocr.*, Part II., p. 111.
 (Not *Amphoracrinus americanus* QUENSTEDT, *Handb. der Petrefactenkunde* [Auf. 3], p. 957, Plate 77,
 Fig. 7, = *Agaricocrinus Wortheni* Hall.)
 Syn. *Agaricocrinus dissimilis* S. A. MILLER; *Adv. Sheets 17th Rep. Geol. Survey Indiana*, p. 55,
 Plate 3, Fig. 11.

Calyx hemispherical, more or less deeply excavated at the bottom. The upper half of the interbrachials and the arm facets are the only parts of the dorsal cup visible from a side view; the basals, radials, and costals occupy the basal concavity, and the distichals and palmars stand more or less at right angles to the vertical axis of the calyx. All plates of the dorsal cup show a slight tendency to become convex, and the suture lines are moderately distinct.

Basals very small, and covered completely by the upper stem joint. Radials small, very little larger than the first costals; their extreme lower edges bending abruptly inward to form the concave base. First costals quadrangular with convex sides. Second costals and first distichals larger than the radials, and their surface generally somewhat more convex than that of the plates below. The first distichal of the three anterior rays, in which there are two arms, is followed by a cuneate second, which interlocks with the first, and with the three lower arm plates of the inner rows. In the two posterior rays, which have three arms — exceptionally four — the divisions next to the anal side have but one distichal and two palmars. Arms heavy at the base, but tapering all the way up to the tips, where they end in a sharp point. They are composed of two rows of short joints, with slightly convex outer faces, which give off rather stout and long pinnules. Interradial spaces somewhat depressed at the arm bases; the anal side very much the widest. First anal plate longer than the radials, and longer than wide; it is followed by a second anal and two interbrachials, one at each side, the latter rising almost to a level with the arm bases, and beyond the upper end of the second anal. The next row generally consists of two short plates, which are succeeded by numerous small, irregularly arranged, convex pieces, which form a large, abruptly protruding lateral anal protuberance, with the opening in the middle. First interbrachial of the regular sides

narrow and very long, curving abruptly from the basal concavity to the upper edge of the dorsal cup, then tapering and rising somewhat beyond the second interbrachials which lie at both sides of it; the latter forming extremely narrow strips, which rest against the curved up lateral faces of the second distichals. Ventral disk subpyramidal, the interrarial spaces slightly depressed; plates highly convex, except the interambulacral pieces, which are almost flat and considerably smaller. Surface of the plates finely granulose. The posterior oral, which is as large as any two of the others, and slightly excentric in position, is surrounded by eight plates: viz., the four smaller orals, two large anal pieces, and two radial dome plates of almost the same size as the orals. Near the periphery there is over each ray another large radial plate, and over the posterior ray toward the anal side a second smaller one, which is wanting in the rays with two arms. The interambulacra consist of five to six pieces, and two other plates overlies the ambulacra. Column comparatively narrow; the nodal joints slightly wider, with convex outer faces.

Horizon and Locality.—Keokuk group; White's creek, near Nashville, Tenn., and Pilot Knob, near Louisville, Ky.

Type in the Mineralogical Museum at Breslau.

Remarks.—This species is remarkable for the extreme length of its first interbrachial pieces, rising as they do to the top of the dorsal cup, and the great tumidity of the anal area, which, together with the form of the calyx, distinguishes it readily from the other species.

In 1878* we placed *Agaricocrinus bullatus* Hall, *A. excavatus* Hall, and *A. nodosus* Meek and Worthen as synonyms under this species. Since then we obtained a large number of additional specimens, especially from the typical locality, which show that these forms can be specifically separated.

***Agaricocrinus Americanus*, var. *tuberosus* (Hall) W. and Sp.**

Plate XL. Fig. 6, and Plate XLII. Fig. 4.

1850. TROOST; List of Crin. Tenn. (Proceed. Am. Ass. Adv. Sci. Cambr. Meet., p. 60).

1850. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 617, Plate 16, Figs. 2a, b, c.

The specimens for which we propose this variety have been generally regarded as synonymous with *A. americanus*. A comparison, however, of

* Proceed. Acad. Nat. Sci. Phila., p. 240.

authentic specimens from White's creek near Nashville, Tenn., Roemer's typical locality, with those from Iowa and Illinois, which Hall described and figured as *Agaricocrinus tuberosus*, shows that the latter are sufficiently distinct to be recognized at least as a variety. The two forms resemble each other in their general outlines, but the lower face of the calyx in the Iowa specimens is considerably more concave; their first interbrachials shorter and not visible in a side view, or but very slightly; the plates of the dorsal cup are somewhat more convex, and the anal area is less tumid, and not so abruptly protruding as in the typical form of *A. americanus*.

Horizon and Locality. — Keokuk group, Keokuk, Iowa, and at Hamilton, Nauvoo, and Niota, Ills.

Types in the collection of Wachsmuth and Springer.

***Agaricocrinus Wortheni* HALL.**

Plate XXXIX. Fig. 9, and Plate XL. Figs. 5a, b, c, d.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 619, Plate 16, Fig. 1.

1881. W. and SF.; Revision Palæocr., Part II., p. 113 (Proceed. Acad. Nat. Sci. Phila., p. 287).

A large species. Calyx depressed pyramidal, pentagonal as seen from above or below, the anal side broadly and deeply excavated, and the posterior rays distinctly lobed. The plates of the dorsal cup to the middle of the second costals placed within a deep concavity, which contains not only the basals, radials and first costals, but the whole of the first interbrachials and parts of the second. All succeeding plates of the dorsal cup are stretched out almost horizontally, and only the arm facets and the third row of interbrachials are visible in a side view. The plates within the concavity are perfectly flat; while all radial plates from the second costals up are more or less convex.

Basals slightly projecting beyond the column. Radials nearly as long as wide. The first costals fully as large, or even larger than the radials; hexagonal, their upper angles truncated by the second interbrachials. Second costals about twice as large as the first; wider, but not as long. First distichals almost as large as the upper costals, their width much greater. The second distichals, when represented, are wider than the first, but half their length. The posterior rays, which have three or four arms, have but one distichal in one or both divisions, which supports on each side a rather large palmar, and this, which is formed like an axillary, is followed by the two rows of arm plates. Arms twelve to fourteen, long, stout, tapering; com-

posed of two series of ninety or more joints to each series. Interbrachials: 1, 2, 3; the first very short and small for the genus, not rising to the full height of the first costals; the two of the second row twice as long as the first and very narrow; the plates of the third range quite variable in form and size, and partly interambulacral. First anal plate larger than the radials, and longer than wide; deeply truncated at the upper angles for the support of two large, elongate interbrachials, which enclose a narrow second anal. There are four to five plates in the next range, which are followed by numerous small, irregular pieces, forming a flattened area containing the anus, which is directed obliquely upwards; the plates of this area grow smaller as they approach the anus, which is located midway between the posterior oral and arm regions, and opens out laterally. Ventral disk depressed conical; the orals and radial dome plates large and covered with heavy rounded nodes, which extend over the whole surface of the plates; the intervening pieces are comparatively small and but slightly convex. Posterior oral extremely large, and separated by small perisomic plates from the other four, and similar plates are interposed between the latter, so each oral is isolated. There is one large radial dome plate over each anterior ray, and two over each posterior one, the second plate being placed above the division with two arms. The interambulacral plates are quite numerous, and cover over the origin of the ambulacra.

Horizon and Locality. — Upper part of the Keokuk group; Keokuk, Iowa, and Hamilton, Ills.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — This species is readily distinguished from *A. americanus* by its larger size, the hexangular form of the first costals, the different arrangement of the interbrachial pieces, the isolated condition of the orals, and the flatness of the anal area.

***Agaricocrinus excavatus* HALL.**

Plate XXXIX. Figs. 3, 4, 5.

1861. *Agaricocrinus excavatus* — HALL; Prelim. Descr. New Spec. Crin., p. 3.
 1861. *Agaricocrinus (Amphoracrinus) excavatus* — HALL; Bost. Journ. Nat. Hist. Vol. VII., p. 282.
 1877. *Amphoracrinus excavatus* — S. A. MILLER; Catal. Amer. Palæoz. Foss., p. 70.
 1893. *Agaricocrinus excavatus* — WHITFIELD; Mem. Amer. Mus. Nat. Hist., 1893, Vol. I., p. 26, Plate 2, Figs. 14, 16.

Smaller than the two preceding species. Calyx pyramidal, a little wider than high; the radial portions projecting outward and downward so as to

produce depressions at the interrarial spaces. Bottom of the dorsal cup deeply excavated to the middle of the second costals, the distichals thus forming the base upon which the calyx rests. All plates within the concavity are flat; while the distichals are more or less convex, and sometimes covered with indistinct transverse angularities.

Basals small, more deeply depressed than the surrounding plates, and hidden from view by the column; the axial canal moderately small and pentangular. Radials more than twice as wide toward the upper end than at the lower; the lower margins inflected to form the basal concavity. First costals one half wider than long, the upper face wider than the lower; they are quadrangular in outline, although frequently one or both upper angles are slightly truncated by the second interbrachials. Second costals as large as the radials or larger, six to eight-sided. Distichals 2×2 , twice as long as the arm plates, interlocking with their fellows of the opposite division, and with the arm plates to the third row. Arms two to the ray, long, very heavy in the lower portions, but gradually tapering until quite thin toward the extremities. Interbrachials three; the first comparatively short, often not reaching the top of the first costals; the two succeeding ones unusually long and extremely narrow, rising from within the basal concavity to a level with the arm bases; these plates support three elongate, moderately large interambulacra, which are followed by six to eight smaller ones. First anal higher than the brachials; supporting on its sloping upper sides two rather large interbrachials, and on the middle face an elongate anal piece; the next row generally consists of four plates, which rise to the height of the arm bases. Ventral disk depressed pyramidal in its anterior aspect, the posterior side greatly protruding outward and upward, and formed into a large anal process, which rises beyond the top of the posterior oral, and from 4 to 6 mm. above the plane of the ventral disk. It is narrower at the base than at the upper end, and somewhat depressed around the anus, which opens obliquely upwards. Orals and radial dome plates large and tuberculous; the former in contact laterally; the latter separated from one another, and from the orals, by small perisomic plates. Column small for the size of the species.

Horizon and Locality.—Uppermost part of the Upper Burlington limestone; Burlington, Augusta, and Pleasant Grove, Iowa.

Remarks.—This species is readily distinguished from *A. americanus* by the very different size, form, and arrangement of its interbrachial plates,

and the more extravagant form of the anal protuberance. *A. Wortheni* is a much larger species, and its anal area throughout is perfectly flat.

Agaricocrinus nodosus MEEK and WORTHEN.

Plate XLIII. Fig. 9.

1869. MEEK and WORTHEN; *Proceed. Acad. Nat. Sci. Phila.*, p. 167.

1873. MEEK and WORTHEN; *Geol. Rep. Illinois*, Vol. V., p. 397, Plate 10, Figs. 7a, b.

Closely resembling *A. excavatus*, and perhaps a mere variety of that species. It agrees with it in the general form of the calyx, the convexity of the dorsal cup, and the form and arrangement of the basals and radials; the first costals, however, are somewhat shorter, and always quadrangular owing to the greater length of the first interbrachials; while the second costals for the same reason are generally octagonal. The latter plates, like the first interbrachials, are larger, and their upper portions, which do not take part in the basal concavity, are strongly convex or even nodose. Also the first distichals, which next to the axillary costals constitute the largest plates of the calyx, are decidedly convex, and so to some extent are the interbrachials of the second row, which are narrow and rise to a level with the arm bases. Second distichals small and cuneate, not extending out to the full width of the first, the outer ends being occupied by the succeeding arm plate, which meets it from the opposite side. The posterior rays have toward the anal side but one distichal, which is axillary, and supports from each side a palmar. Arms twelve, not quite as stout as in *A. excavatus*, and the anal process less protuberant.

Horizon and Locality.—Upper part of the Upper Burlington limestone, Pleasant Grove, Des Moines Co., Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks.—This and the preceding species were placed by us in Part II. of the Revision (p. 112) with *Agaricocrinus americanus*, with which they both have close affinities.

Agaricocrinus bullatus HALL.

Plate XLI. Figs. 2a, b, c, d.

1858. HALL; *Geol. Rep. Iowa*, Vol. I., Part II., p. 562, Plate 9, Figs. 11a, b.

Syn. *Agaricocrinus pentagonus*—HALL, 1860; *Suppl. Geol. Rep. Iowa*, p. 57; and Whitfield, *Amer. Mus. Nat. Hist. N. York*, 1893, Vol. I., p. 25, Plate 2, Figs. 17, 18.

Of medium size. Calyx depressed pyramidal, distinctly pentangular below the arm bases, and rather deeply concave at the bottom. The con-

cavity is formed by the basals, radials, and the lower portions of the first interbrachials, which are stretched out horizontally, and form the flat bottom; the first costals constitute the sides, while the second costals and the upper portions of the interbrachials deflect outward and slightly upward, and form the rim upon which the calyx rests; the latter plates are a little convex, those within the convexity are flat. Suture lines well defined.

Basals concealed by the column. Radials nearly as long as wide, the lower margins deflected to form the columnar depression. First costals quadrangular, nearly twice as wide as long, bending abruptly upwards on their lower margins; the second larger and throughout wider than the first, often larger even than the radials. First distichals quite variable, in some specimens almost twice as large as in others; they are succeeded by a single cuneate plate, or by two pieces, the edge of the one overlapping the other. Arms ten; contiguous to the third plate above the axillary; stout, but shorter than in any of the preceding species. First interbrachials subovate, very large, sometimes twice as large as the radials; they rise to the middle of the first distichals, where they are followed by two long, very narrow pieces, which reach up to the level of the arm openings. The first anal, which is narrower and higher than the radials, supports three large plates, the middle one narrower than the two outer, and there are three others in the next range. Posterior oral somewhat excentric, leaning to the posterior side, very large and strongly nodose; it is surrounded by nine or ten plates consisting of the smaller orals, which are less tumid and of but half its size, two somewhat smaller radial plates, and three to four small, almost flat, supplementary anal pieces. The radial plates near the outer margin of the disk are somewhat larger than the smaller orals. Interambulacral plates not numerous, there being rarely more than five to each side. Anal area wide and flat; the anus placed midway between the arm regions and the summit of the posterior oral; the opening directed laterally. Column very small compared with the size of the species; joints of almost uniform width; axial canal pentangular.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa, and at the same horizon in Illinois and Missouri.

Type in the Illinois State collection at Springfield.

Remarks. — This species resembles *A. Wortheni* Hall, in general outlines, and has a similar flattened anal area, but the latter is a much larger species,

has a different arm formula, and the orals are separated from one another by supplementary plates.

Hall's *A. pentagonus* is undoubtedly synonymous with this species. The type specimen is unusually high and narrow, and this accounts for the narrowness of its first interbrachial plates.

***Agaricocrinus splendens* S. A. MILLER.**

Plate XL. Figs. 1a, b, c.

1891. S. A. MILLER; Journ. Cincin. Soc. Nat. Hist., Vol. XIII., Plate 4, Figs. 1 and 2; also 17th Rep. Geol. Surv. Indiana, p. 55, Plate 8, Fig. 10.
 Syn. *Agaricocrinus indianensis* S. A. MILLER; *ibid.*, p. 53, Plate 8, Fig. 5.
 Syn. *Agaricocrinus Gorbyi* S. A. MILLER; *ibid.*, p. 54, Plate 8, Fig. 9.

Smaller than any other species from the Keokuk group. Calyx depressed pyramidal, width and height as five to three, distinctly pentalobate across the arm facets, the interradial spaces wide and rather deeply excavated. Dorsal cup deeply concave to the top of the first distichals, the second distichals and proximal arm plates spreading outward with a slight upward tendency. Plates almost flat; suture lines moderately well marked.

Basals hidden by the column. Radials small. First costals as large as the radials, quadrangular, as long as wide or even longer; the second heptangular, about as long as the first but considerably wider. Distichals decidedly long for the genus; the second followed by two series of transverse arm plates, except in the two posterior rays where in the division approaching the anal side the arm plates are supported by the first palmar. Arm facets contiguous to the second or third arm plate, directed slightly upward. Arms twelve, stout at their bases, slender at their tips. Pinnules long and heavy, composed of short joints. Interradial spaces a little sloping, so as to give some prominence to the radial portions. First interbrachial elongate, rising to the middle of the second costals, where it is followed by two narrow plates of the same length as the first, and a third plate which rests between the lateral extensions of the proximal arm plates. First anal plate a little longer than the radials; it supports three large plates, of which the middle one is longer than the two at the sides; they are followed by a large number of irregular rows of from four to five pieces, which form a rounded ridge, extending from near the bottom of the calyx to the summit of the posterior oral, and which is somewhat inflated in the middle around the anal opening. The posterior oral is highly convex, almost as large as the other

four together; it is separated from the latter, and these from one another, by rather large supplementary pieces, even in the smallest specimens. Similar plates intervene between the orals and radial dome plates, and pass over the ambulacra. The radial dome plates, which are comparatively small, occupy the margin of the tegmen.

Horizon and Locality.—Keokuk group, Indian creek, Montgomery Co., Ind., where large numbers of excellent specimens were obtained.

Remarks.—The construction of the tegmen is the most characteristic feature of this species. The isolated orals, protruding anal ridge, and the small radial dome plates, separate it at once from allied forms. The posterior rays occasionally have four arms, but the other rays never more than two, and on a specimen of this kind Miller's *Agaricocrinus Gorbyi* is based.

***Agaricocrinus Whitfieldi* HALL.**

Plate XLII. Fig. 3, and Plate XLIII. Figs. 8a, b.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 621.

1860. HALL; Ibid., Supplement, Plate 3, Fig. 5.

1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 499, Plate 12, Figs. 1a, b, and Plate 15, Fig. 8.

1881. W. and SP.; Revision Palæocr., Part II., p. 113.

Calyx rather large, depressed subhemispherical; the dorsal cup deeply concave, so that the lower end of the calyx rests upon the first distichals.

Basals entirely hidden by the column. Radials small, wider than long, hexangular. First costals slightly smaller than the radials, quadrangular or pentangular, rarely hexangular; the second costals varying from pentangular to heptangular, and considerably larger than either radials or first costals, especially wider. First distichals very large, of unequal size; the second shortest, and followed by the biserial arms, except in the posterior rays, in which the divisions next to the anal side have palmars from the first distichals. Arm facets large; the arm structure unknown. First interbrachials short, rising generally to the middle of the first costals, but sometimes touching the second; plates of the second row very long and narrow, curving abruptly upward to half the height of the arm facets, where they are followed by still narrower ones, which in part are interambulacral. First anal narrower than the radials; the two plates at the sides of the second anal, which are much longer than the first interbrachials of the other sides, on a level with the lower part of the distichals; the next row consisting of

five smaller plates, which are succeeded by numerous others. Ventral disk low hemispherical, the plates perfectly flat, except the first radial dome plates, which are slightly nodose, very large, and placed near the arm bases. Orals in contact laterally; the posterior one central, twice as large as the others, and interposed between them. Interambulacral plates very numerous, and forming a continuous ring around the orals, covering completely the disk ambulacra; those of the anal side are somewhat smaller, and as numerous as all other interambulacral plates together. There being no anal ridge, the plates of the posterior area grow smaller as they approach the anus, which is excentric and directed obliquely upwards.

Horizon and Locality.—Keokuk group; Green Co., Ills., and Keokuk, Iowa.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks.—This species differs from all others of the same horizon in the peculiar structure of the disk. It is only found in the shaly layers, which constitute the middle part of the Keokuk group, and good specimens are extremely rare.

Agaricocrinus nodulosus WORTHEN.

Plate XL. Fig. 2, and Plate XLIII. Figs. 7a, b.

1891. Geol. Rep. Illinois, Vol. VIII., p. 94, Plate 13, Figs. 1, 1a.

Calyx broadly pyramidal with slightly concave sides. Its lower face deeply excavated to the middle of the first distichals, forming a rounded, inverted cup, of which the posterior side is deeply notched, while the margin toward the other sides inclines but very little. The calyx, when placed upon its dorsal side, rests upon the distichals, and while the interbrachial plates of the four regular sides almost touch the bottom, those of the anal side are more remote, leaving, when viewed from the side, a large, triangular vacant space. The plates occupying the basal concavity, comprising the basals, radials and costals, are perfectly flat; the distichals and palmars, however, which form its surrounding margin, are more or less convex, and the bases of the arms almost touch the bottom of the calyx.

Basals rarely visible beyond the column. Radials somewhat irregular in size, the posterior ones generally longer than the others. First costals quadrangular, once and a half as wide as long, their lateral faces convex; the second as large as the radials and pentangular. Distichals quite variable in form and size, as well as in number among the rays. In the anterior ray,

which generally has but two arms, there are 3×2 distichals; while in the rays with three or four arms, the second distichal is axillary in one or both divisions, and is followed by two rows of palmars. Arms $\frac{1}{2}$, exceptionally three in the anterior ray, which are free above the second palmar, or third distichal respectively, and they are heavy, long, and tapering. Pinnules stout, composed of joints which are nearly three times as long as wide. First interbrachial narrow and long, rising to the middle of the first distichals; the two plates of the second range as long as the first, but only half as wide. First anal longer than the radials, and longer than wide; the second anal elongate, widest at the upper end, the interbrachials at the sides widest in the middle, all curving from within the lower concavity abruptly upward. Anus in the middle of an oval shaped protuberance, opening obliquely outward. Orals in contact laterally; all convex, the posterior one a little the largest. The ambulacra are represented not only by the usual number of radial dome plates, but by additional plates, either placed in one or two series. Rays with three arms have a single large secondary radial dome plate at one side, but those with four arms have one at each side. The interambulacral spaces are somewhat depressed, and are occupied by a few small, irregular plates.

Horizon and Locality. — Keokuk group; Keokuk, Iowa, Jersey Co., Ills., Montgomery Co., Ind., White's creek, Tenn., and Canton, Ind.

Types in the Illinois State collection, Springfield.

Remarks. — Differing from all preceding species in the greater number of arms, and in the form and proportions of the calyx.

***Agaricocrinus nodulosus*, var. *Macadamsi* (WORTHEN).**

Plate XXXIX. Fig. 6.

1891. *Agaricocrinus Macadamsi* WORTHEN; Geol. Rep. Illinois, Vol. VIII., p. 94, Plate 13, Figs. 2, 2a.

The specimen for which Worthen proposed the above name, agrees in the most essential points so closely with *A. nodulosus*, that we think it is only a variety. Yet there are some differences; the specimens as a rule are larger, and differ considerably in the form of the calyx, which is high-hemispherical, as opposed to depressed subpyramidal in the other. The sides of the ventral disk are inflated below, the top being almost flat, and the orals are larger and but very slightly convex. In the structure of the dorsal cup the two forms are almost identical, and they have the same number of arms.

Horizon and Locality.—Keokuk group; Hamilton, Ills., Keokuk, Iowa, and Montgomery Co., Ind.

Type in the Illinois State collection, Springfield.

Agaricocrinus crassus WETHERBY.

Plate XXXIX. Figs. 2a, b, and Plate XL. Fig. 4.

1881. WETHERBY; Journ. Cincin. Soc. Nat. Hist., Vol. IV., p. 178, Plate 5, Figs. 1, 1a, b.

1885. W. and SP.; Revision Palæocr., Part III., p. 105.

A large and robust form; calyx more distinctly lobate than in any other species of this genus. Dorsal cup almost twice as wide as high, its base but very little concave, the second row of interbrachials abruptly bent upward, and the brachials above the first costals inflected, which combined gives to the calyx a decidedly stelliform aspect. Plates massive and a little convex; suture lines moderately distinct.

Basals covered by the column. Radials quite irregular, the two posterior ones fully one half longer than the others, all hexagonal in outline, their extreme lower ends bending inward to form the sides of the basal concavity. First costals as large as the radials, generally quadrangular, the lower face narrower than the upper, and about equal to the length. Second costals the largest plates of the dorsal cup, twice as wide as long, and as a rule heptagonal, rarely pentagonal or hexagonal. The number of distichals varies considerably; all ray divisions with palmars have but one distichal, which, being axillary, is followed by 2×2 palmars; those without palmars have two successive distichals, which are from three to four times as long as the lower arm plates. Arm facets of the same ray contiguous to the third arm plate, and directed horizontally. Arms three to four in the two posterior rays, in the other rays their number is limited to two. Interradial spaces comparatively wide, especially at the anal side; the first interbrachial generally rises to the middle of the second costals, and is elongate, bending slightly upward. Of the second range of interbrachials only the lower end is visible in a dorsal aspect; they are rather broad, extend to a level with the arm openings, and are followed by a number of from eight to ten interambulacral pieces, one or two of them covering over the ambulacra. First anal plate longer than the posterior radials; the three plates above almost as wide as the corresponding single piece of the other sides; the next row consists of four or five smaller plates, and these are followed by numerous irregular pieces forming a slightly elevated area, which at midway between

the arm regions and the summit of the posterior oral is pierced by the anal opening. Orals in contact laterally, large and highly convex; the posterior one twice as large as the smaller orals, or larger and equally tumid.

Horizon and Locality.—Keokuk group; Keokuk, Iowa; Barren and Metcalf Cos., Ky.; White's creek near Nashville, Tenn., and Indian creek, Montgomery Co., Ind.

Types in Professor Wetherby's collection.

Remarks.—This species is readily recognized by its stellate form, the very slight concavity of the dorsal cup, and by the form and arrangement of the plates.

***Agaricocrinus elegans* WETHERBY.**

Plate XL. Figs. 3a, b.

1881. WETHERBY; Journ. Cincin. Soc. Nat. Hist., Vol. IV., p. 179, Plate 5, Figs. 4, 4a, b.

1885. W. and Sp.; Revision Palæocr., Part III., p. 106.

Nearest to *A. crassus*, but smaller and less robust. Calyx depressed, pentalobate in a dorsal aspect, with rather deep recesses between the rays; the base moderately excavated. Plates of the dorsal cup slightly tumid, basals and radials excepted; the principal plates of the ventral disk highly convex.

Basals hidden by the column. Radials smaller than the costals. First costals quadrangular, hexangular or heptangular, as wide as long; the second costals wider than the first, and about as long. First distichals axillary in one or both divisions of the posterior rays, supporting 2×2 moderately large palmars; the other rays have two successive distichals, which interlock with those of opposite series, and with the arm plates above. Arm facets tending slightly upward, confluent to the second arm plates. Arms three to four in the posterior rays, and two in the other rays. First interbrachials comparatively short, generally rising to the first costals, sometimes to the second. The plates of the second row long, reaching to near a level with the arm openings; they support a row of three or four smaller plates, which are partly interbrachial, partly interambulacral. Anal area extremely wide; the first plate narrower than the radials, and but very little longer, the three succeeding ones almost as large; the latter support three smaller plates, and these numerous other plates, which form together a longitudinal, slightly elevated ridge, which at half way to the orals is pierced by the anus. Ventral disk pyramidal. Orals large and highly convex, the posterior one in

contact with the others. The radial dome plates as large as the orals, and represented in the posterior rays by plates of a first and second order, in the other rays by a primary plate only. Interambulacral spaces depressed, the plates almost flat. Column proportionally large.

Horizon and Locality. — Keokuk group; Keokuk, Iowa, and Niota, Ills.

Type in the collection of Professor Wetherby.

Remarks. — Wetherby's description is so general and indefinite, that a satisfactory identification of the species is impossible without a comparison with the type, which is not available at present.

Agaricocrinus conicus W. and Sp. (nov. spec.).

Plate XXXIX. Figs. 7, 8.

Of medium size. Calyx conical, rather high, width and height as 6 to 5; in its dorsal aspect irregularly pentalobate, the recess between the posterior rays twice as wide as between the others, and the rays themselves stronger and projecting out farther. Dorsal cup moderately excavated to the middle of the first costals; plates slightly convex; suture lines distinct.

Basals concealed by the column. Radials varying in size, the two posterior ones larger than the others. First costals considerably wider at the top than at the bottom, their length equal to, or exceeding, the lower width; three of them hexangular, the two posterior ones pentangular. Second costals pentangular, as long as the radials and twice as wide; the posterior ones hexangular. The distichals in the posterior rays consist of a single plate, which is as large as the second costals, and axillary; supporting 2×2 palmars, which are twice as long as the arm plates. Rays with but two arms have two successive distichals, which in form and size resemble the palmars. Arm facets directed horizontally, contiguous to the second row of arm plates. Arms broadly spreading, and moderately heavy at their bases. Interbranchials short, rarely reaching the top of the first costals; the two plates of the second row as long as the first, and almost as wide, the three of the third smaller. First anal plate smaller than the posterior radials, but shorter than the second costals; the interbranchial plates enclosing the latter rather large, rising to the second costals; they are followed by three as wide but somewhat shorter plates, and numerous others, which together form a flat area with a slight swelling around the anus. Posterior oral as large as the others together, and in contact with them. The food grooves hidden by superimposed interam-

bulacral pieces, with occasionally a larger covering plate among them. Interambulacral plates very numerous and comparatively flat; anal opening lateral.

Horizon and Locality — Keokuk group; Indian creek, Montgomery Co., Ind.

Types in the collection of Wachsmuth and Springer.

Remarks. — The specimen on Plate XXXIX., Fig. 7, is exceedingly interesting as having on three of its arms well defined cysts, similar to those produced in recent Crinoids by *Myzostoma*, and it appears as if portions of the parasites are still preserved on the fossil. This is the first instance where such cysts have been noticed on the arms of Palæozoic Crinoids.

***Agaricocrinus inflatus* HALL.**

Plate XLI. Figs. 1a, b, c, d.

1861. *Agaricocrinus inflatus* — HALL; Prel. Des. New Pal. Foss., p. 4.

1861. *Agaricocrinus (Amphorocrinus) inflatus* — HALL; Bost. Journ. Nat. Hist., Vol. VII., p. 284.

1877. *Amphorocrinus inflatus* — S. A. MILLER; Catal. Amer. Palæoz. Foss., p. 70.

1881. *Agaricocrinus inflatus* — W. and SP.; Revision Palæocr., Part II., p. 112 (Proceed. Acad. Nat. Sci. Phila., p. 286).

A robust species, in form approaching *Amphorocrinus*; the symmetry extremely irregular. Calyx as high as wide and obscurely pentalobate; the interradial spaces at the arm regions slightly impressed. The whole lower face of the calyx flat or concave; the second interbrachials, the upper edges of the first, and the arm facets the only parts of the dorsal cup visible in a side view. Ventral disk highly elevated, broad at the top, and enormously inflated at the posterior side. The plates throughout the calyx are but slightly convex, barely enough to bring out distinctly the suture lines; only the posterior oral is more or less nodose, and sometimes subspinous.

Basals hidden within the column concavity; axial canal sharply pentangular. Radials a little wider than long, the sides rapidly spreading, the lower end thickened, forming a circular ridge around the columnar depression. First costals fully twice as wide as long, quadrangular, three of their sides convex, the upper straight. Second costals wider, and sometimes longer than the first, the sides spreading abruptly. Distichals 2×2 ; the plates short and cuneate, meeting laterally with their pointed ends, their wider faces directed to the outer sides of the rays, whereby the facets of the confluent arms are brought into an even line; contrary to the case of other

species, in which they meet at an angle. Arms very long and heavy, less tapering than usual in this genus. First interbrachial large, subovate, the upper end curved, rising to one fourth the height of the arm facets; it is followed by two or three smaller, elongate pieces, of which the third, when present, is wedged in from above between the other two, frequently without touching the first plate. First anal higher and narrower than the radials, supporting a second anal and two rather large interbrachials. Ventral disk strongly inflated at the anal side, the anal opening directed upward, located in the middle of a flattened area, which extends beyond the summit of the posterior oral, making that side of the disk lean out of a perpendicular beyond the line of the dorsal cup. The plates in the lower part of the tegmen are perfectly flat, some of the upper ones slightly elevated, but not nodose, except the posterior oral. This plate which is extremely large and excentric, is pushed with the other orals to the anterior side, and stands erect, forming a part of the lateral walls of the calyx. The radial dome plates cannot be distinguished from the interambulacrals, and probably in some cases were not exposed at all. Interambulacral plates quite numerous, especially on the anal side. Column rather large, the nodal joints a little wider and with rounded edges.

Horizon and Locality. — Upper Burlington limestone, Burlington, Iowa.

Type in the White collection in the University at Ann Arbor.

Remarks. — The enormous inflation of the posterior side, making the whole calyx sometimes appear to lean to one side, the excentricity of the orals, and the flatness of all the plates, distinguish this species quite readily from all others of the genus.

***Agaricocrinus planoconvexus* HALL.**

Plate XXXVIII. Figs. 6a, b, c.

- 1861. *Agaricocrinus planoconvexus* — HALL; Prelim. Descr. Palæoz. Crin., p. 3.
- 1861. *Agaricocrinus (Amphoracr.) planoconvexus* — HALL; Bost. Journ. Nat. Hist., Vol. VII., p. 280.
- 1870. *Amphoracrinus planoconvexus* — S. A. MILLER; Catal. Amer. Palæoz. Foss., p. 70.
- 1881. *Agaricocrinus planoconvexus* — W. and Sp.; Revision Palæocr., Part II., p. 112.
- Syn. *Agaricocrinus decornis* ROWLEY and HARE, 1891, Kansas City Scient., p. 117, Plate 3, Fig. 10.
- Syn. *Agaricocrinus Blairi* S. A. MILLER; 1892, Adv. Sheets 18th Rep. Geol. Surv. Indiana, p. 21, Plate 3, Figs. 12, 13, 14.

This species probably has its closest affinities with *A. inflatus*, but its calyx is smaller, proportionally shorter — the height and width being as 3 to 5 — and less inflated at the posterior side. It is distinctly pentangular in a

dorsal view, and the bottom part is wholly or partly excavated. The calyx, when placed in an upright position, rests either on the costals or distichals, and leaves very little of the dorsal cup but the arm facets and second range of interbrachials exposed in a side view. Plates of the dorsal cup flat, and suture lines obscure; those of the tegmen flat also, but their sutures are somewhat depressed.

Basals hidden from view, forming the bottom of the column concavity. Radials longer than wide, rapidly spreading. First costals rather large, quadrangular, their upper faces wider than the lower; the second shorter, twice as wide as long and pentangular. Distichals two in the calyx, very short, especially the upper, which has a subcircular facet, and at the ventral side is deeply notched by the ambulacral groove. Arm facets large, and those of the same ray directed at right angles. Interradial spaces somewhat contracted at the arm regions; the first plate fully twice as long as wide, and attenuate at the upper end; the two of the second range quite narrow, resting against the first distichals, and rising to a level with the arm openings. First anal plate one third narrower than the radials and slightly longer; the second anal narrow and long, narrower at the lower end than at the upper; the plate at each side widest across the middle. Ventral disk low hemispherical; the posterior side slightly inflated, but forming no ridge or lateral groove. Anus in close proximity to the posterior oral, the opening turned obliquely upward. Posterior oral the only plate of the tegmen which is convex; the other orals and the radial dome plates being not only flat but comparatively small; the former somewhat pointed at the outer end.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the University Museum at Ann Arbor.

Remarks. — The depressed form of the ventral disk, the flatness of its plates, the absence of any anal ridge, and the shortness of the costals and distichals, are the most characteristic features of this species.

A. decornis Rowley and Hare, and *A. blairi* S. A. Miller, of which we examined the types — the former in the collection of Mr. Rowley, the other in that of Mr. F. A. Sampson — are identical with this species. The latter was described from the Chouteau group, but the color of the fossil and the matrix seem to indicate that it came from the Lower Burlington limestone. The subquadrangular outline of the calyx, to which Miller alludes as a specific distinction, is caused by the abnormal anterior ray of the specimen, in

which one of the arms is undeveloped, a peculiarity which we have observed occasionally also in other species of this genus.

Agaricocrinus Sampsoni S. A. MILLER.

Plate XLVI. Fig. 5.

1892. S. A. MILLER; Adv. Sheets 18th Rep. Geol. Surv. Indiana, p. 20, Plate 3, Fig. 8.

A moderately small species, remarkable for its massive arms, which are proportionally heavier than in any other species known to us. Calyx apparently short; the dorsal cup slightly convex; the basal portions flat or very little concave; the interradial spaces rapidly curving upwards, so as to give to the cup a pentangular outline.

Basals small, but extending beyond the sides of the column. The radials the largest plates of the calyx, wider than long; their sloping lower faces more than twice as long as the corresponding upper ones. First costals subquadrangular, short, but longer than figured by Miller. Second costals a little longer than the first, irregular in outline, the upper angle obtuse. Distichals one, as large as, or larger than the axillary costals, more than twice as wide as long, wedgeform, the larger outer ends bending inward. Arms two to the ray, massive, gradually tapering; biserial from their origin; those of the same ray suturally united as high as the second row of plates; the arm joints rather long and slightly convex. Regular interbrachials one, moderately large, pentangular, a little longer than wide. Anal plate one third narrower than the radials, but somewhat longer; the three plates of the second row narrow; the two outer ones cuneate, their wider ends resting against the sloping upper faces of adjoining radials; the sides of the middle plate almost parallel. Ventral disk not visible in the specimen.

Horizon and Locality. — Chouteau limestone, near Chouteau Springs, Mo.

Type in the collection of Mr. F. A. Sampson.

Remarks. — The type specimen, which Mr. Sampson was kind enough to send us for examination, lies upon a slab with its arms spreading horizontally, so that its whole ventral side is covered by matrix. We regard *Agaricocrinus germanus* and *A. chouteauensis*, both described by Miller, of which only the calyx is preserved, as identical with this species; the former being a young specimen, the latter a more adult one.

Agaricocrinus bellatrema HALL.*Plate XLI. Figs. 4a, b, c, d.*

1861. *Agaricocrinus ornotrema** — HALL; Prelim. Descr. New Palæoz. Foss., p. 3.
 1861. *Agaricocrinus (Amphorocrinus) bellatrema* — HALL; Bost. Journ. Nat. Hist., Vol. VII., p. 281.
 1877. *Amphorocrinus bellatrema* — S. A. MILLER; Catal. Amer. Palæoz. Foss., p. 70.
 1881. *Agaricocrinus ornotrema* — W. and SE.; Revision Palæocr., Part II., p. 112 (Proceed. Acad. Nat. Sci. Phila., p. 286), and Whitfield, 1893, Mem. Am. Mus. Nat. Hist. N. York, Vol. I., p. 24, Plate 2, Figs. 19, 22.

Calyx subpyramidal in its anterior aspect; the posterior side inflated and strongly protruding; the base completely flat or very slightly convex, and distinctly pentangular in outline.

Basals hidden by the column, the latter resting within a small concavity formed by the lower margins of the radials; axial canal pentalobate. Radials wider than long. The first costals smaller than the second and quadrangular; the latter about twice as wide as long, pentangular, not larger than the radials. Distichals 1×2 ; the plates cuneate, short, and followed by two series of short arm plates. Arm facets very large, and those of the same ray contiguous up to the third plate. Arms ten, quite heavy at the base, but gradually tapering and ending in a sharp point. Pinnules long and stout; their joints twice as long as wide. First interbranchials the largest plates of the calyx, and the only ones of the dorsal cup which sometimes are slightly convex; subovate, reaching to one half the height of the arm facets, and supporting two narrow pieces, which rise to a level with the arm openings. First anal plate longer and generally narrower than the radials; the second anal somewhat smaller, the two interbranchials to each side of the same form as the corresponding single plate of the other interradial, but from a third to a half smaller. The next row consists of three plates, of which the two outer ones, in part at least, are interambulacral. The ventral disk at the posterior side bulges considerably upward and outward, forming an inflation which, owing to its large size, disturbs considerably the general symmetry. The median portion of this inflation, the part containing the anus, consists of a subovoid, flattened area, which is directed obliquely upward. The space is covered by small plates, and these in turn are surrounded by eight or ten moderately large, strongly nodose or subclavate pieces, a structure which gives to the anal area, and in fact to the

* The name *Agaricocrinus ornotrema* was originally given to this species, but not being properly formed, was afterwards changed by Hall to *A. bellatrema*.

whole calyx, a peculiar and unique character. Posterior oral strongly nodose, and almost as large as the four others together; it occupies a slanting position, leaning over to the anterior side, where it occupies a lower level than at the posterior side. The smaller orals and radial dome plates highly convex, about twice as large as the intervening perisomic plates. Interambulacral pieces seven to nine to each side, slightly convex. The column, which has been observed to the length of nearly eighteen inches, retains the same width to the end. The nodal joints throughout are considerably wider and longer than the intervening ones, and at about 10 cm. from the calyx the internodes have increased to six joints, which is probably the largest number in this species. Farther down on the stem, larger and smaller joints alternate with one another.

Horizon and Locality.—Upper Burlington limestone, Burlington and Pleasant Grove, Iowa.

Type in the White collection at Ann Arbor, Mich.

Remarks.—This species is readily distinguished by the peculiar construction of the anal area, the asymmetry of the calyx, and the flatness of the dorsal cup.

***Agaricocrinus bellatrema*, var. *major* W. and Sp. (nov. var.).**

Plate XLI. Fig. 5.

This form differs from the typical *A. bellatrema* in the size and form of the calyx, which is larger and depressed-sphæroidal in place of subpyramidal, the dorsal cup being slightly more convex, and the ventral disk shorter. As a rule, the plates of both hemispheres are more tumid, but especially those of the ventral disk, which throughout are sharply nodose, the interambulacral pieces as well as the others; and all plates, excepting the posterior oral, are of about uniform size. The plates of the dorsal cup are but very slightly convex. The construction of the anal area is the same as in the typical form.

Horizon and Locality.—Same as last.

Described from three specimens in the collection of Wachsmuth and Springer.

Agaricocrinus stellatus HALL.*Plate XXXVIII. Figs. 7a-e.*

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 564.

1881. W. and SP.; Revision Palæocr., Part II., p. 113.

Syn. *Agaricocrinus geometricus* HALL; 1860, Suppl. Geol. Rep. Iowa, p. 56.

A small species, resembling *A. bellatrema* in the form of the dorsal cup, and *A. bullatus* in the construction of the tegmen. Calyx subpyramidal, wider than high, and distinctly pentangular across the arm facets, the sides a little constricted. Lower face of the dorsal cup somewhat convex, the basals and radials a little concave, or the radials stretched out horizontally and only the basals depressed. Plates flat, with shallow grooves along the suture lines.

Basals sometimes extending beyond the column. Radials about as wide as long, the upper face twice as wide as the lower. First costals a little smaller than the radials, quadrangular, wider than long, and the upper face wider than the lower. Second costals pentangular, exceptionally hexangular or heptangular, generally a little wider than the first. Distichals 2×2 in the calyx; the upper one followed by two series of free brachials. Arm facets large, directed horizontally or nearly so; those of the same ray forming an angle of 60° . Arms ten, stout, gradually tapering, and composed of rather long joints. Interbrachials one and two; the first rising generally to the top of the first distichals; the two of the second row, which are narrow and long, come to a level with the arm openings. First anal much longer than the radials, followed by two rows of three plates. The upper part of the anal area is composed of irregular pieces forming a well defined ridge, which near its upper end contains the anus. Posterior oral large and spinous, the four others and the radial dome plates highly convex; interambulacral pieces almost flat.

Horizon and Locality.—Lower layers of the Upper Burlington limestone; Burlington, Iowa, and at several places in Illinois and Missouri.

Type in the (Worthen) Illinois State collection, Springfield.

Agaricocrinus convexus (HALL) W. and SP.*Plate XXXVIII. Figs. 1a, b.*1860. *Agaricocrinus pentagonus*, var. *convexus* — HALL; Suppl. Geol. Rep. Iowa, p. 58.1861. *Agaricocrinus convexus* — W. and SP.; Revision Palæocr., Part II., p. 112.

A very different species from *A. pentagonus*, to which it has been referred by Hall, in some respects approaching *Amphoracrinus*. Calyx pentalobate, indented between the rays. Dorsal cup depressed saucer-shaped; the ventral disk irregularly hemispheric, bulging at the posterior side. The plates of the former flat, the radials and first interbranchials sometimes a little concave; those of the tegmen more or less tumid; suture lines distinct but not actually grooved.

Basals hidden by the column. Radials large for the genus, as long as wide; their lower margins deflected to form the column concavity. First costals quadrangular, once and a half as wide as long; wider above than below; three of its faces convex, the upper straight. Second costals not longer than the first but wider, the upper angle quite obtuse. Distichals two, short and wide; the upper one cuneate and followed by two rows of alternately arranged arm plates. Arms two to the ray, not quite as heavy as in some of the preceding species; gradually tapering. First interbranchials very large, rising to the first distichals; width and length as three to four. They are followed by two elongate plates, and these by a moderately large number of interambulacral pieces. Anal side very wide. The first anal longer than the radials, but not as wide; supporting three plates, which are remarkable for their width, being almost as wide as long. The next row consists of four to five small pieces, which support in the disk numerous others of irregular form. The pentamorous symmetry of the ventral disk is considerably disturbed by the large anal area, which bulges conspicuously from above the arm regions to the posterior oral; it is, however, unlike that of *A. bellatrena*, being composed of almost flat pieces, and bordered by a shallow groove at each side. Anal opening directed obliquely upwards. Posterior oral excentric, being pushed over to the anterior side; it is as large as three of the others together, and strongly nodose, while the others are but little convex. The radial dome plates, if represented at all, were small, not much larger than the interambulacrals, which in this species are quite numerous.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Remarks. — Hall described this species as a variety of *Agaricocrinus pentagonus* as follows: "Base convex; arms small; all the plates of the dome tuberculous." Not only is this description insufficient, but it is partly incorrect; the plates of the tegmen being convex but not tuberculous. The present description was made from a specimen in the collection of Wachsmuth and Springer.

Agaricocrinus Corey (LYON and CASS.).*Plate XXXIX. Figs. 1a, b.*

1860. *Actinocrinus Corey* — LYON and CASSEDAY; Amer. Journ. Sci. (sec. ser.), Vol. XXIX., p. 76.

Syn. *Agaricocrinus Springeri* — WHITE, 1881; Eleventh Ann. Rep. Geol. and Nat. Hist. of Indiana, p. 363, Plate 40, Figs. 2, 3, 4.

Of more than medium size. Calyx a little shorter than wide. Dorsal cup rather high for the genus, but somewhat lower than the ventral disk, saucer-shaped, truncated at the bottom, the sides convex. Plates elevated, sometimes a little angular, their surface smooth; suture lines distinctly grooved.

Basals rather small; on a level with the radials, and forming a hexagon, which is almost completely hidden by the column. Radials stretched out horizontally, except the uppermost part which bends slightly upward; they are twice as large as both costals together, and one third wider than long; their upper faces excavated and broader than the width of the plate at the bottom. Costals twice as wide as long, the first quadrangular, the second pentangular and frequently smaller than the first. Distichals two in the calyx, very short; the first wedge-shaped; the second linear, followed by leaf-like cuneate pieces, which interlock from opposite sides. Arm facets lunate, unusually large and directed horizontally. Arms unknown, but apparently very stout. First interbrachial large, generally longer than wide, followed at the arm regions by two elongate pieces in the second row, and these by seven to eight interambulacral plates. First anal plate considerably longer than the radials, and forming with the two succeeding ones a vertical row; second anal about one half the size of the first, the third very much smaller. Both these plates rest between two interbrachial pieces, of which those in the first row are very large, but those of the second quite small. Ventral disk pyramidal, pentangular in outline, the plates convex. Posterior oral conical, central in position, and three times as large as the four others. Interambulacral plates rather numerous, about one fourth the size of the smaller orals. The rays are surmounted by a large radial plate, placed close to the lower margin of the disk. Anus excentric, directed obliquely upward, and occupying the upper end of an elongate, distinctly rounded area, composed of small, smooth, irregular pieces.

Horizon and Locality. — Keokuk group; Hardin and Allen Cos., Ky., and Vermilion Co., Ind.

Type in the Lyon collection.

Agaricocrinus brevis (HALL).*Plate XXXVIII. Figs. 2a-e.*1858. *Actinocrinus brevis* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 567, Plate 10, Figs. 3a, b.1881. *Agaricocrinus brevis* — W. and Sp.; Revision Palæocr., Part II., p. 112.Syn. *Actinocrinus corniculus* — HALL, 1858, Geol. Rep. Iowa, Vol. I., Part II., p. 566, Plate 10, Figs. 1a, b, c.

A small and delicate species. Calyx wider than high; dorsal cup and tegmen of the same height. The lower part of the dorsal cup to the top of the radials slightly concave, thence spreading rather abruptly to the arm bases; the interradial spaces slightly depressed and somewhat contracted at the arm regions. All plates below the arm regions thickened, and rising above the suture lines in nodose or tuberculous extensions, with short, inconspicuous ridges reaching to the sides of the plates, where they meet with the ridges from adjoining plates.

Basals small, forming the bottom of the column depression. Radials a little longer than wide, their ridges occupying only the upper end of the plates, the convex lower part being perfectly smooth. First costals small, quadrangular, the sides convex; the second pentangular, shorter than the first but wider. Distichals 2×2 , very short, supporting the arms. Arm facets large, subcircular; the ambulacral openings larger than usual in this genus. Arms ten, heavy, slightly increasing in thickness to half their height, then tapering gradually, and ending in a sharp point. First interbrachials large, nearly as wide as long, rising to the top of the first distichals; the two plates of the second row very narrow, three times as long as wide. First anal plate a little narrower than the radials; the three plates above, which are almost as large as the corresponding single plate of the four regular sides, are followed by four or five small pieces, and these by numerous rows of still smaller ones, which form a ridge, with a well defined groove at the sides. Ventral disk comparatively short, hemispherical, with a large plate in the centre. This plate, which represents the posterior oral, and is almost as large as three of the other orals, is surrounded by eight slightly convex plates, four of them orals, two overlying the posterior ambulacra, and two the anal side. The radial dome plates, which are so prominent in other species, either are unrepresented, or cannot be distinguished from the inter-ambulacral pieces, which are of moderate size, and only sufficiently tumid to bring out distinctly the suture lines. Anus directed laterally, located half way between the arm openings and the summit of the posterior oral.

Horizon and Locality.—Lower Burlington limestone; Burlington, Iowa, and southern Missouri.

Type in the (Worthen) Illinois State collection.

Agaricocrinus fiscellus (HALL).

Plate XXXVIII. Figs. 3a, b, c.

1861. *Actinocrinus fiscellus* — HALL; Boston Journ. Nat. Hist., Vol. VII., p. 272.

1881. *Agaricocrinus fiscellus* W. and SP.; Revision Palæocr., Part II., p. 112.

Of the same size as *A. brevis*, and so closely resembling it that it is questionable whether it is not a mere variety of that species. It differs somewhat in the proportions of the calyx, the dorsal cup being comparatively higher, and the tegmen shorter. It is also more distinctly pentalobate, the inter-radial depressions at the arm bases being deeper. In the ornamentation of the plates the two species are similar, if not identical. In the form under consideration, the plates to the top of the radials are horizontal, and those above curved abruptly upwards, with little increase in the width of the calyx. The basals form a hexagon with a shallow depression in the centre for the reception of the column, leaving the outer margins of the basal disk exposed. Radials wider than long, the upper part a little nodose, but without ornamentation. There are two distichals in both divisions of the three anterior rays, and also in one of the divisions of the two posterior ones; while the divisions next to the anal side have but one, which is axillary and supports at each side a short palmar, making three arms to these rays against two in the others. The arm facets are smaller than in *A. brevis*; the arms not quite so heavy, but apparently a little longer. Tegmen very short, depressed hemispherical; the posterior oral large and sharply conical; the other plates slightly convex. The anal area is formed as in the preceding species, but is somewhat more bulging.

Horizon and Locality. — Same as last.

Type in the University Museum at Ann Arbor, Mich.

Agaricocrinus pyramidatus (HALL).

Plate XXXVIII. Figs. 4a, b, c, and 5a, b, c.

1858. *Actinocrinus pyramidatus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 565.

1881. *Agaricocrinus pyramidatus* — W. and SP.; Revision Palæocr., p. 112; and 1893, Whitfield, Mem. Amer. Mus. Nat. Hist., Vol. I., p. 23, Plate 2, Figs. 23 and 25.

Syn. *Agaricocrinus corrugatus* HALL; 1861; Prelim. Descr. New Palæoz. Foss., p. 4, and Boston Journ. Nat. Hist., p. 283.

Another small species of the type of *A. brevis*, but its calyx shorter and of somewhat different form, being about twice as wide as high, and pyramidal in outline. Dorsal cup sharply pentangular and distinctly flattened at the bottom. When placed on end, it rests upon the costals, the basals and radials forming a shallow, funnel-shaped concavity, and the distichals bending slightly upward. The costals and distichals curve to the sides, so as to form a depression at the interradian spaces, and each plate has a narrow, transverse, angular ridge. The suture lines are distinctly grooved.

Radials rapidly spreading; their upper faces twice as wide as their lower, the upper end thickened, corresponding to the transverse ridges of the brachials. First costals very short, more than twice as wide as long; the second a little wider and longer in proportion. Distichals almost as short as the free arm plates; the second considerably wider than the first, and followed by two series of arm plates, of which the two inner series of the ray interlock with the second free plate, *i. e.* fourth plate from the axillary. Arm facets large, confluent, and those of adjoining rays almost in contact. Arms ten, massive at the bases, quite thin at the extremities; composed of two rows of short parallel joints, with transverse, obscurely angular ridges. First interbrachials large, attenuate at the upper end, their surfaces convex; the two of the second range long and extremely narrow. The first anal, which is fully as long but not as wide as the radials, is followed by three elongate plates, and these by a large number of irregular pieces, forming a slightly rounded, ridge-like elevation, with a groove at each side. Anus close to the posterior oral, opening out obliquely upward. Ventral disk depressed pyramidal; the orals and radial dome plates distinctly convex, the interambulacra almost flat.

Horizon and Locality. — Same as last.

Types in the (Worthen) Illinois State collection, and in the University Museum at Ann Arbor, Mich.

***Agaricocrinus gracilis* M. and W.**

Plate XLI. Figs. 3a, b, c.

1861. MEEK and WORTHEN; *Proceed. Acad. Nat. Sci. Phila.*, p. 135.

1881. W. and SP.; *Revision Palæocr.*, Part II., p. 112.

Somewhat smaller than *A. brevis*; the calyx wider than high; in its ventral aspect decidedly pentangular with concave sides. Dorsal cup de-

pressed, the bottom concave to the middle of the first costals, which together with the first interbrachials and second anal plate are geniculated, or abruptly bent upward, and swollen so as to form a circle of hemispherical nodes around the margin of the concavity; the upper portions being almost vertical. Ventral disk depressed pyramidal, with a short conical spine at the summit. Surface of plates throughout the calyx finely granulose, and sufficiently convex to bring out the suture lines.

Basals hidden from view, occupying the bottom of the column concavity. Radials about as wide as long, all hexangular in outline. First costals slightly larger than the radials and quadrangular; the second not longer than the first, but often considerably wider, and provided with an obtuse mesial ridge, which connects with the prominences upon the first. The distichals from the second up are free. The arm facets have a slightly upward tendency, and those of the same ray are placed at right angles; arms a little longer and more slender than in *A. brevis*. Interradial spaces wide and somewhat depressed in the upper portions, a little contracted at the arm regions. First interbrachial large, curving abruptly upward; followed by two elongate pieces, and a small quadrangular one, the latter occupying the arm regions. The interambulacral plates consist of five or six pieces. The two lower anals vary considerably in size; the first being in some specimens not longer than the radials, in others almost twice as long. In the latter case the first takes part in the circle of nodes which form the lower margin of the calyx, in the other it occupies together with the radials the lower concavity, and the second anal is nodose and forms a part of the circle; the interbrachials at the sides of the second anal are elongate and widest in the middle. The next row consists of three smaller plates, which are succeeded by numerous irregular still smaller ones, forming an almost flat area. Anus directed laterally and placed low down, a little above the arm openings. Posterior oral large, high conical or subspinous; the four others are scarcely elevated. The radial dome plates somewhat projecting and moderately convex.

Horizon and Locality.—Upper Burlington limestone, Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks.—The circle of tumid plates at the lower margin of the calyx distinguishes this species from all others.

HABROCRINUS Angelin.

Subgenus **ACACOCRINUS** W. and Sp.

("Ακακος simple, κρίνον a lily.)

Calyx short, cyathiform. Basals three, equal. Radials rather large. Costals two. The distichals giving off the arms, which remain simple, and are composed of cuneate pieces alternately arranged, interlocking or not. Interbranchials in contact with the interambulacrals. Anal side wide, composed of numerous plates arranged in longitudinal rows, of which there are generally three. Interdistichals not observed. Structure of ventral disk and form of anus not known. Column round and large.

Distribution. — Only known from the Niagara group of Indiana.

Type. — *Acacocrinus Elrodi*.

Remarks. — We attempted at first to place the following two species under *Carpocrinus*, but were unable to do so. Joh. Müller proposed this genus for "die mit den *Actinocrinus* bisher vereinigten Crinoideen, denen auch das unregelmässige *interradiale* aller wahren Crinoideen fehlt." His definition does not apply to *Carpocrinus simplex*, Müller's type, if Angelin's and Zittel's identifications are correct, for it has, according to their statements, an anal plate interposed between the radials. This, it seems to us, disqualifies Müller's name from further use, and it will have to be replaced by *Habrocrinus* Angelin. But from this, and from the subgenus *Desmidocrinus*, our form differs, at least the typical species, in having cuneate interlocking arm pieces in place of transverse single joints in *Habrocrinus*, which we think is sufficient to separate the two forms subgenerically, as all other species of *Habrocrinus* have rectangular arm plates.

Acacocrinus Elrodi* W. and Sp. (nov. spec.).

Plate XXXIV. Fig. 16.

A small species, not over 24 mm. from the top of the stem to the top of the arms. The plates of the dorsal cup a little convex and smooth; the median line of the costals and distichals slightly angular. Basals forming a rather large obconical cup, truncated at the end. Radials very large, as long as wide or a little longer, larger than the two costals together, the upper face concave. Costals wider than long; the second smaller than the

* Named in honor of Dr. Moses N. Elrod, one of the pioneer geologists of Indiana, who collected the only known specimen.

first. Arms moderately long, filiform at their upper ends; composed of cuneate joints, interlocking to biserial. Pinnules comparatively strong, and composed of very long joints. Interbrachials: 1, 2, 2; the first considerably larger. Anal side very wide; the first anal smaller than the radials, followed by a series of four other anals longitudinally arranged, and having at each side, and in contact with them, rows of 1, 2, and 2 plates.

Horizon and Locality. — Niagara group; Hartsville, Bartholomew Co., Ind.

Type in the collection of Wachsmuth and Springer.

Acacocrinus americanus W. and Sp. (nov. spec.).

Plate XXXIV. Figs. 15a, b.

Dorsal cup obconical, wider than high; the sides convex, spreading more rapidly from the top of the basals to the top of the radials; the interrarial spaces flattened and the cross section obscurely pentangular. Plates but very little convex, their surfaces apparently smooth, the suture lines not grooved. Basals forming a shallow, slightly spreading cup. Radials as large as both costals together, a little longer than wide; the upper face concave. First costals generally quadrangular, the posterior ones occasionally pentangular; the second costals pentangular or hexangular, the angle at the upper face very obtuse. Distichals one only preserved in the specimen, quadrangular in outline, as long as the costals but much narrower. First interbrachial almost as large as the radials, and about as wide as long; the second row consisting of two much smaller plates. Anal plate somewhat smaller than the radials, and the three plates above not more than half the size of the first interbrachial of the regular sides; the succeeding row consisting of three pieces of the size of the distichals. All other parts unknown.

Horizon and Locality. — Niagara group; St. Paul, Ind.

Type in the collection of Wachsmuth and Springer.

COMPSOCRINUS S. A. MILLER.

1883. S. A. MILLER; Journ. Cincin. Soc. Nat. Hist., Vol. VI., p. 233.

Syn. *Glyptocrinus* (in part) — MILLER; 1881; *ibid.*, Vol. IV. (April number), Plate I., Fig. 6.

Syn. *Mariocrinus* (in part) — W. and Sp.; 1885, Revision Palæocr., Part III., p. 104 (Proceed. Acad. Nat. Sci. Phila., 1885, p. 326).

In its general habitus resembling *Glyptocrinus*, but having an anal plate between the radials, and only four basals. Basals large, unequal, two of

them angular above, the other two truncated, one of the latter supporting the first anal, the other the anterior radial. Radials generally wider than the two costals. Distichals two when palmars are represented, but five or more if these are wanting. In the latter case a stout pinnule from the second distichal takes the place of an arm, and the plate above is not pinnule-bearing. Arms long and slender, composed of cuneate single pieces. Pinnules stout, given off alternately from opposite sides. Interbrachials, interdistichals, and interpalmars numerous; the anal side wider, with a longitudinal row of anal plates, followed by a strong ridge. Ventral disk composed of minute irregular pieces. Position of anus unknown. Column quadrangular; axial canal small, pentangular; the angles interradially disposed.

Distribution. — Upper part of the Hudson River group of Ohio.

Remarks. — *Compsocrinus Harrisii*, the type of the genus, was originally described by Miller under *Glyptocrinus*, and nothing was said of the first anal forming a part of the radial ring. Neither was this noticed in 1883 in Miller's generic description of *Compsocrinus*, but his diagram shows it, and he also stated it in the revised specific description. The structure was overlooked by us in 1881 when we referred the species to *Mariacrinus*. Since then we have discovered that Miller's "*Glyptocrinus*" *miamiensis* also belongs to this genus, having a quadrangular stem, and four basals supporting six plates.

***Compsocrinus Harrisii* S. A. MILLER.**

Plate XXI. Figs. 8a, b.

1881. *Glyptocrinus Harrisii* — S. A. MILLER; Journ. Cincin. Soc. Nat. Hist. Vol. IV. (April number), Plate 1, Figs. 4, 4a.
 1883. *Compsocrinus Harrisii* — S. A. MILLER; *ibid.*, Vol. VI., p. 234, Plate 11, Figs. 4, 4a.
 1885. *Mariacrinus Harrisii* — W. and SP.; Revision Palæocr., Part III., p. 104.

A small highly ornamented species. Calyx higher than wide; rapidly expanding to the middle of the first costals, less spreading above; interradiar areas depressed. Surface covered with prominent ridges, arranged into well defined stars with intervening triangular depressions. Radial ridges wide and prominent, occupying one half the width of the plates, rounded on the back, and wider at the ends of the plates than at the middle. The ridges toward the interbrachials lower and flattened at the top, but like the radial ridges stoutest near the suture lines, a peculiarity which is also found at the interdistichals and interpalmars.

Basals small, only their upper angles exposed beyond the column. Radials and costals nearly of uniform size. Distichals two, a little smaller than the costals. Palmars five or six in the calyx, comparatively large, very gradually decreasing in size; succeeded by free arm plates of the same order. Arms twenty, not branching, slender, cylindrical, composed of short cuneiform pieces. Interbrachials: 1, 2, 3, 2, 2, 2, *etc.*; the anal side wider, containing a longitudinal row of anal plates marked by a strong ridge. Interdistichal and interpalmar areas unusually large, the former composed of five or more rows. Construction of ventral disk not known. Column quadrangular, with rounded angles and slightly concave sides.

Horizon and Locality.—Upper part of Hudson River group, Waynesville, O.

Type in the collection of I. H. Harris, Esq., at Waynesville.

Compsocrinus miamiensis (S. A. MILLER).

Plate XXI. Figs. 7a, b.

1882. *Glyptocrinus miamiensis*—S. A. MILLER; Journ. Cincin. Soc. Nat. Hist., Vol. V., Plate 1, Fig. 1.
 1883. *Glyptocrinus miamiensis*—W. and SP.; Amer. Journ. Sci., Vol. XXV., p. 265.
 1883. *Glyptocrinus miamiensis*—S. A. MILLER; Journ. Cincin. Soc. Nat. Hist., Vol. VI., p. 224.
 1885. *Glyptocrinus miamiensis*—W. and SP., Revision Palæocr., Part III., p. 104.

Calyx elongate; the rays followed by strong ridges, which occupy one half the width of the plates. There are no ridges upon the interbrachials or upon any of the other plates, the surface of the calyx is covered with minute, irregularly arranged pustules, which are not readily seen except under a magnifier.

Basals moderately large, forming a good-sized cup; the posterior one largest and broadly truncated above; the truncate face of the anterior one somewhat narrower; the two others forming a right angle. Radials and costals of about equal size, but in the former the proximal side is angular, in the others the distal. The posterior rays have two large distichals, followed by three to four palmars which support the arms; the three anterior rays have from four to five distichals in the calyx and no palmars, giving fourteen arms to the species. Interbrachials: 1, 2, 2, 2, 2, *etc.* The anal side has an additional row of anal plates following the median line. Structure of ventral disk and anal opening unknown. Column obscurely quadrangular, with a small pentangular canal.

Horizon and Locality. — Upper part of Hudson River group; Waynesville, O.

Type in the collection of I. H. Harris, Esq., Waynesville.

B. PERIECHOCRINITES.

PERIECHOCRINUS AUSTIN.

1842. AUSTIN; Ann. & Mag. Nat. Hist., Vol. X., p. 109 (no definition).
 1843. AUSTIN; *ibid.*, Vol. XI., p. 203.
 1843. MORRIS; Catal. Brit. Foss. (Ed. 1), p. 56 (Ed. 2, p. 86).
 1855. MCCOY; Synops. Brit. Palæoz. Foss., p. 56.
 1857. PICTET; Traité de Paléont., Vol. IV., p. 323.
 1859. MURCHISON; Siluria, p. 536.
 1862. DUJARDIN and HUPÉ; Hist. Natur. des Zooph. Echin., p. 137.
 1878. ANGELIN; Iconogr. Crin. Suec., p. 6.
 1879. ZITTEL; Handb. der Palæont., Vol. I., p. 369.
 1881. W. and S.; Revision Palæocr., Part II., p. 127 (Proceed. Acad. Nat. Sci. Phila., p. 301).
 Syn. *Actinocrinites* — J. S. MILLER; 1821, History of the Crinoidea, p. 116.
 Syn. *Actinocrinus* — PHILLIPS; 1839, Murch. Silur. Syst., p. 673, Plate 18, Fig. 4.
 Syn. *Trochocrinites* — PORTLOCK; 1848, Geol. of Londonderry, p. 345.
 Syn. (?) *Pradocrinus* — DE VERNEUIL; 1850, Bull. Soc. Géol. France (ser. II.), Vol. VII., p. 184.
 Syn. *Geocrinus* — D'ORBIGNY; 1850, Prôdr. de Paléont., Vol. I., p. 46.
 Syn. *Saccocrinus* — TROOST; 1850; List of Crin. Tenn. (no description).
 Syn. *Saccocrinus* — HALL; 1852, Palæont. N. York, Vol. II., p. 205.
 Syn. *Pyridocrinus* — MÜLLER; (in part); 1857, Neue Echin. Eidl. Kalk., p. 253.
 Syn. (?) *Trochocrinites* — PANDER, 1858, Helmersson's Geol. Bemerk. auf einer Reise in Sweden, etc., p. 20.
 Syn. *Saccocrinus* — F. ROEMER; 1860, Silur. Fauna West Tenn., pp. 42-44.
 Syn. *Actinocrinus* (*Megistocrinus*) HALL; 1861, Bost. Journ. Nat. Hist., p. 271.
 Syn. *Actinocrinus* (*Pradocrinus*) — M. and W.; 1861, Proceed. Acad. Nat. Sci. Phila., p. 133.
 Syn. *Actinocrinus* — HALL, 1863, Trans. Alb. Inst., Vol. V., p. 196.
 Syn. *Megistocrinus* — WINCH. and MARCY; 1865; (not O. and S.), Mem. Bost. Soc. Nat. Hist., I., p. 87.
 Syn. *Actinocrinus* (*Saccocrinus*) — M. and W.; 1869, Geol. Rep. Illinois, Vol. III., pp. 347 and 470.
 Syn. *Megistocrinus* (*Saccocrinus*) M. and W.; 1873, Geol. Rep. Illinois, Vol. V., p. 397.
 Syn. *Saccocrinus* — HALL; 1879, 28th Rep. N. Y. State Mus. Nat. Hist. (Revised Ed.), p. 127.
 Syn. *Saccocrinus* — S. A. MILLER — Journ. Cincin. Soc. Nat. Hist. of 1881 and 1882.

Calyx large, elongate, bell- or urn-shaped. Plates thin, and their surfaces smooth or delicately sculptured; the radial plates generally having a ridge passing from plate to plate, which increases in prominence upwards until it becomes identified with the free arms.

Basals three, equal, forming a deep cup; column facet wide. Radials and costals long and narrow; constricted at their upper and lower faces, sometimes connected merely by the point of an angle. Costals two, hexangular and heptangular. Distichals in two to four rows; supporting from two to six palmars, except in a few cases where the arms are free above the

distichals. Arms branching in the biserial state; long, slender, rounded; constructed from their bases up of a double series of interlocking pieces. Pinnules slender, closely contiguous. Interbrachial and interdistichal spaces long and narrow, composed of a large number of plates. First interbrachial larger than the succeeding ones; supporting numerous rows of two plates each — rarely three, and only in the upper rows — which pass imperceptibly into interambulacral pieces. Anal interradius very wide; the first anal similar in form to the radials; there are three plates in the next range, and four to six in the succeeding ones. Interdistichals present, and variously represented by from three to six rows. Ventral disk depressed, from moderately convex to almost flat; composed entirely of small, irregularly arranged plates, apparently without orals or radial dome plates, except close to the arms, where sometimes the covering and side pieces enter the margin. Anus subcentral. Column large, cylindrical; axial canal moderately wide and circular.

Distribution. — *Periechocrinus* is found in the Niagara group of America, and its equivalent in England and Sweden. It also occurs slightly modified in the Upper Devonian of Spain, and in the Lower Subcarboniferous of the Mississippi Valley.

Type of the genus: *Periechocrinus moniliformis* (J. S. Miller).

Remarks. — Austin's definition of *Periechocrinus* is not as clear as could be wished, but it is enough to indicate that he refers to a group of Crinoids of which J. S. Miller's well known *Actinocrinus moniliformis* is the type. The species are remarkable for their elongate, sac-like form, the thinness of the plates, the great length and slender form of the radials, the width of the anal interradius, and the branching of the biserial arms, substantially the same characters upon which afterwards Hall undertook to separate the genus *Saccocrinus*.

In the Revision, Part II., we placed under *Periechocrinus* not only the species which had been referred to *Saccocrinus*, but several others from the Lower Carboniferous which had been described variously under *Actinocrinus*, *Megistocrinus*, *Saccocrinus*, and *Pradocrinus*. These species, which embrace *Actinocrinus* (*Megistocrinus*) *Whitei* Hall, *Actinocrinus* (*Pradocrinus*) *amplus* M. and W., and *Actinocrinus tenuidiscus* Hall, resemble *Periechocrinus* in general habitus, but come from a very different geological horizon, have a less elongate calyx, and proportionally shorter plates. They differ still more from *Megistocrinus* by the thinness of their plates, and by having radial ridges. These species we have marked with a query, as it is pos-

sible they may have to be separated subgenerically, perhaps under *Pradocrinus*.

The anus of *Periechocrinus* is rarely observed, and throws no light on the relations of the genus. *P. moniliformis* was probably provided with a short anal tube, while most of the other species seem to have had a mere protuberance.

Pradocrinus de Verneuil (1850) is possibly identical with *Periechocrinus*, and also *Geocrinus* d'Orbigny, which was proposed in the same year. Johannes Müller referred *Pradocrinus* to *Pyxidocrinus*, under which he proposed to embrace all Actinocrinidæ possessing interdistichals. Angelin identified *Trochocrinites* Pander with *Periechocrinus*; while Bigsby took it to be a synonym of *Glyptocrinus*. The name *Trochocrinites* was preoccupied by Portlock in 1848, but *T. lævis*, the only species referred to it, was described from an imperfect specimen, and its relations cannot be accurately determined. Hall's *Actinocrinus semiradiatus*, which is known only from natural casts, and which we formerly referred to *Periechocrinus*, is possibly a *Macrostylocrinus*. S. A. Miller's *Saccocrinus Gorbyi*, from Decatur Co., Ind., is described from a cast, and it is doubtful if it belongs to this genus.

***Periechocrinus speciosus* (HALL).**

Plate L. Figs. 6a, b.

1862. *Saccocrinus speciosus*—HALL; Palæont. N. York, Vol. II., p. 205, Plate 46, Figs. 1, 2.

1881. *Periechocrinus speciosus*—W. and Sp.; Revision Palæocr., Part II., p. 133.

Rather large. Calyx elongate; sides but little convex; greatest width across the first distichals; plates smooth, even without the usual radial ridges.

Basal cup very deep. Radials and costals once and a half as long as wide, decreasing in size in ascending order, their upper and lower faces exceedingly narrow, the upper sloping faces of the radials unusually short. Distichals four; the first about half the size of the first costals; the second much smaller; the upper ones, which are followed by free arm plates, short and quadrangular. Arms branching a little above the calyx, and twice again higher up; they are proportionally thin and taper gradually to the tips. Interbrachials rather large; the first followed by five or six ranges of two plates each. Interdistichals in three or four rows. Construction of the anal side not known, nor the structure of the tegmen. Column round; the nodal joints slightly projecting; their edges covered with a row of small nodes,

those of the intervening joints angular; the axial canal rather large and circular.

Horizon and Locality. — Niagara group, above the shales; Lockport, N. Y.

Types in the American Museum at New York.

Remarks. — *P. speciosus*, which was made by Hall the type of *Saccocrinus*, is the only known American *Periechocrinus* in which the second bifurcation takes place in the arms.

***Periechocrinus Whitfieldi* (HALL).**

Plate LI. Figs. 1, 2a, b, 3, 4.

1863. *Actinocrinus Christyi* — HALL; Trans. Alb. Inst., Vol. IV., p. 196. (Abstr., p. 2), not *Actinocrinus Christyi* Shum., 1855.
 1868. *Actinocrinus Whitfieldi* — HALL; 20th Rep. N. Y. State Cab. Nat. Hist. (Doc. Edit.), p. 326.
 1863. *Saccocrinus Christyi* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. III., p. 347, Plate 5, Fig. 1.
 1870. *Actinocrinus (Saccocrinus) Whitfieldi* — HALL; 20th Rep. N. Y. State Cab. Nat. Hist. (Revised Ed.), pp. 370 and 430.
 1877. *Saccocrinus Christyi* — S. A. MILLER; Catal. Amer. Palæoz. Foss., p. 90.
 1879. *Saccocrinus Christyi* — HALL; 28th Rep. N. Y. State Cab. Nat. Hist. (Revised Ed.), p. 127, Plate 13, Figs. 12-20.
 1881. *Periechocrinus Christyi* — W. and SP.; Revision Palæocr., Part II., p. 132.
 1881. *Saccocrinus Christyi* — HALL; 11th Ann. Rep. Indiana, p. 254, Plate 12, Figs. 12-20, Plate 15, Figs. 3, 4.

A moderately large species. Calyx subovate; the dorsal cup urn-shaped, its sides convex and but slightly spreading below the arm bases; the ventral disk low hemispherical, the plates thin and flat, the radial ridge proceeding from the middle of the radials to the arms rather obscure. Surface of plates finely granulose, the granules arranged in excentric lines, parallel to the margins of the plates.

Basals large, more rapidly spreading than the succeeding plates. Radials and costals decreasing in size upwards; the radials nearly three times as large as the second costals, and longer than wide, the upper and lower faces much smaller than any of the others. Distichals two, of the size of the second costals, supporting two or three small palmars, which are succeeded by the arms, the structure of which is not known. Interbrachials: 1, 2, 2, 2, sometimes with a sixth row within the arm regions; the plates, as a rule, are longer than wide, and agree in size with adjoining brachials. Interdistichals 1, 2, 2; the lower one larger, resting between the first distichals. Anal interradius very wide; the anal plate of equal width with the radials, but not quite as long; the three plates of the second row longer than wide; the middle plate the narrowest; the third row also consists of three plates,

and is followed by other rows of five or six pieces. Ventral disk paved by a large number of small, smooth, irregular plates, apparently without orals, but small covering and side pieces enter the margin. Column near the calyx composed of very short pieces; central canal of medium size.

Horizon and Locality. — Niagara group; Waldron, Ind.

Remarks. — *Megistocrinus marcouanus* and *M. infelix* Winch. and Marcy, which Hall has regarded as identical with this species, are probably distinct.

***Periechocrinus marcouanus* (WINCH. and MARCY).**

Plate L. Figs. 7a, b, and Plate LI. Fig. 5.

1865. *Megistocrinus marcouanus* — WINCHELL and MARCY; Mem. Boston Soc. Nat. Hist., Vol. I., p. 87, Plate II., Fig. 5.
 1879. Syn. of *Saccocrinus Christyi* — HALL; 28th Rep. N. Y. State Mus. Nat. Hist. (Revised Ed.), p. 127.
 1881. *Saccocrinus marcouanus* — S. A. MILLER; Journ. Cincin. Soc. Nat. Hist., Vol. IV., p. 167, Plate 4, Figs. 1, 1a.
 1885. *Periechocrinus marcouanus* (?) — W. and SF.; Revision Palæoer., Part III., p. 106.

A very large and elongate species; the calyx sometimes reaching a length of 75 mm. by about 40 mm. in width across the arm bases; form subovoid, the width greatest at the top of the second costals, whence it contracts to the third distichals, there expanding again to the arm bases. Interbrachial and interdistichal areas somewhat flattened or faintly depressed, producing a sort of angularity along the median line of the radial series, without forming an actual ridge until close to the arms. Surface of plates smooth, the suture lines not grooved.

Basals comparatively small, forming a saucer-shaped, hexagonal cup. Radials and costals of nearly the same size and of similar form, their lateral faces concave to receive the convex sides of adjoining interbrachials. Second costals as long as the first, and nearly as wide; the upper and lower faces in both of them narrow; the upper sloping sides longer than the lower. Distichals three, decreasing in size upwards; the first nearly as long as the costals, and almost as wide, its upper face quite narrow; the second of the same proportions but smaller; the third much shorter. Palmars numerous, comparatively small, shorter than wide, those of the same divisions in lateral contact. Arms four to the ray, arranged in pairs; their first bifurcations close to the calyx. Interbrachial spaces long and narrow; they consist of one plate in the first row, followed by from ten to twelve ranges of two plates each, which meet the plates of the tegmen. Anal interradius very wide; first anal plate a little shorter than the radials, but wider at the upper face;

the three plates above succeeded by three plates, and numerous other plates irregularly arranged in rows of from five to six pieces each, which grow smaller as they approach the tegmen. Upon the ventral disk there is a well defined anal ridge, which ends in a subcentral probosciform protuberance with the anus at the upper end. Interdistichals consisting of a rather large plate resting between the sloping upper faces of the first distichals, and six or more rows of two plates each, the upper ones resembling the plates of the tegmen. Tegmen almost flat; composed exclusively of small polygonal plates. In the casts there appear upon the surface ten well marked ridges, which represent grooves in the test for the reception of the ambulacra.

Horizon and Locality. — Upper part of Niagara group; near Chicago, Ills.

Remarks. — It probably occurs also at Waldron. Among the specimens which we refer to it there is one in which large portions of the arms are preserved. They branch at about 18 mm. above the calyx, and one of the branches again at about 25 mm. above the first bifurcation. Whether any additional bifurcation takes place in this species, cannot be ascertained, as the arms are broken at 65 mm. from the calyx. The arms are composed of two rows of short, transverse pieces, very regularly arranged.

***Periechocrinus necis* (WINCH. and MARCY).**

Plate L. Figs. 1a, b.

- 1865 *Megistocrinus necis* — WINCHELL and MARCY; Mem. Bost. Soc. Nat. Hist., p. 110, Plate 2, Fig. 6.
 1881. *Saccoocrinus necis* — S. A. MILLER; Journ. Cincin. Soc. Nat. Hist., Vol. IV., p. 172, Plate 4, Figs. 3, 3a.
 1885. *Periechocrinus necis* — W. and SP.; Revision Palæocr., Part III., p. 106.

A shorter species than the preceding. Calyx pyriform, not much higher than wide; obconical to the top of the second radials; greatest width a little above the second costals, whence it contracts rapidly to the arm bases, at which the calyx is reduced to two thirds its former width. Surface of plates smooth, with slight angularities following the radials, giving to the cross-section a somewhat pentangular outline.

Basals of medium size, more rapidly spreading than the parts above. Radials and costals occupying two thirds the height of the calyx, nearly of equal size, longer than wide; their upper and lower faces wider than usual in this genus. Distichals two; the first plate one third smaller than the costals; the second as much as one half. Palmars two or more, small, and between them are interposed 1, 2, 2, small interdistichals. Interbranchials

rather large, decreasing gradually in size; disposed generally in six rows, of which the upper ones are irregular and not readily recognized; the first plate, which has the size of the first costals, supports two plates in the second row, and three in the succeeding ones. Anal interradius wide, the first anal plate as large as the radials; succeeded by three plates, the middle one the smallest, and four or five plates in the rows above. Tegmen almost flat, its diameter remarkably small, owing to the constriction at the upper regions of the dorsal cup. In the casts there are no traces of disk ambulacra, and nothing to indicate the presence of orals in this species; the whole surface is covered by the impressions of small, irregular plates, surrounded by what appears to represent the arm openings, which were apparently arranged in groups, forming a circle around the disk. The exact number of primary arms could not be ascertained from the specimens, but we have reason to believe there were eight arms to the ray. Anus subcentral, apparently not large.

Horizon and Locality. — Upper part of Niagara group, near Chicago, Ills.

***Periechocrinus infelix* (WINCH. and MARCY).**

Plate L. Figs. 2a, b, c, d.

1865. *Megistocrinus infelix* — WINCHELL and MARCY; Mem. Bost. Soc. Nat. Hist., p. 110, Plate 2, Fig. 7.
 1879. Syn. of *Saccocrinus Christyi* — HALL; 28th Rep. N. Y. State Mus. Nat. Hist., p. 127.
 1881. *Saccocrinus infelix* — S. A. MILLER; Journ. Cincin. Soc. Nat. Hist., Vol. IV., p. 260, Plate 6, Figs. 2, 2a, b.
 1885. *Periechocrinus infelix* (?) — W. and SP.; Revision Palæocr., Part III., p. 106.
 Syn. *Saccocrinus Egani* — S. A. MILLER; Journ. Cincin. Soc. Nat. Hist., Vol. IV., p. 173, Plate 4, Figs. 4, 4a.

Smaller than the two preceding species. Dorsal cup somewhat obconical, higher than wide; sides convex, abruptly spreading from the basals to the top of the radials; the upper regions almost cylindrical, sometimes a little spreading; surface of plates slightly convex, and covered with obscure radiations.

Basals small, forming a shallow pentangular cup. Radials and costals rising to three fourths the height of the calyx; the radials much wider than the first costals, about as wide as long, and the sloping upper faces almost as short as the upper face; the first costals, as a rule, a little larger than the second. Distichals two, one third smaller than the preceding axillary. Palmars two, small. Interbrachial and interdistichal areas somewhat grooved at the upper ends. Interdistichals disposed in six to seven rows; the first as large as the first costals, with obtuse upper angle and long lateral faces, great-

est width about one fourth its height; succeeding plates in rows of two, the upper ones small and irregularly arranged. Anal interradius wide, depressed between the arm bases, and forming at the ventral surface a rounded ridge, which connects with the anus; the plates very numerous and irregularly arranged. Interdistichals generally 1, 2, 2. Ventral disk low-convex, the interambulacral spaces depressed, the plates nearly flat. The food grooves in the cast are delineated by prominent ridges, which bifurcate half way out to the arms, and again close to the arm bases, giving off in the calyx four arms to the ray.

Horizon and Locality. — Upper part of Niagara group, near Chicago, Ills.

Remarks. — This species was regarded by Hall as a synonym of *Periechocrinus Whitfieldi*, but we agree with Miller that the two forms are distinct. The plates of *P. Whitfieldi* are flat and finely ornamented, those of *P. infelix* convex and without ornamentation; the radials of the former possess prominent ridges, which are wanting in the other. We disagree with Miller, however, as to his "*Saccocrinus*" *Egani*, which we take to be identical with *P. infelix*.

***Periechocrinus urniformis* (S. A. MILLER).**

Plate L. Figs. 5a, b.

1881. *Saccocrinus urniformis* — S. A. MILLER; Journ. Cincin. Soc. Nat. Hist., Vol. IV., p. 170, Plate 4, Figs. 2, 2a.
 1885. *Periechocrinus urniformis* (?) — W. and Sp.; Revision Palæocr., Part III., p. 106.
 Syn. *Saccocrinus pyriformis* — S. A. MILLER; 1882, Journ. Cincin. Soc. Nat. Hist., Vol. V., p. 81, Plate 3, Fig. 3.
 Syn. *Periechocrinus pyriformis* (?) — W. and Sp.; Revision Palæocr., Part III., p. 106.

Only known from internal casts. Calyx large, ovoid; greatest width across the arm bases, which are somewhat projecting; plates gradually decreasing in width upwards.

Basals small, forming a rather low cup. Radials and costals nearly of equal size; their width across the middle equal to their height; the upper and lower faces less constricted than in the preceding species. Distichals two, the first one fourth, and the second as much as one half, smaller than the costal axillaries. Palmars two, small. Interbrachial and interdistichal areas on a level with surrounding brachials, except close to the arm bases, where they form rather wide, well marked depressions, which are continued upon the tegmen. First interbrachial of about the same size as the first costal, but pentangular in place of hexangular; succeeded by six to seven rows of

two plates each. Interdistichals, 1, 2, 2; the first resting within the notch of the first distichals. Anal side remarkably wide. The anal plate, which closely resembles the radials, followed by three rather large plates, and these by three smaller ones and an elongate plate at each side, which latter rise to the top of the plates of the third row, so that the second and third rows together contain eight plates. This arrangement, however, is not invariable; there are some specimens in which these rows have five plates each, and the plates above, on approaching the tegmen, form a rounded, conspicuous ridge, which connects with the anus. The course of the ambulacra is indicated in the casts by well marked ridges, which branch twice upon the surface, and show that there was a third bifurcation in the calyx. Ventral disk hemispherical, composed of rather uniform pieces of moderate size. Anus subcentral.

Horizon and Locality. — Upper part of Niagara group; Chicago, Ills.

Remarks. — We have carefully compared Miller's types of his "*Saccocrinus*" *pyriformis* with the types of *Periechocrinus urniformis*, both in the collection of Mr. Egan of Chicago, and came to the conclusion that the differences pointed out in the descriptions are not constant, and are to a large extent imaginary.

(?) *Periechocrinus ornatus* (HALL).

Plate L. Figs. 3a, b, and Plate LI. Fig. 7.

1875. *Succocrinus ornatus* — HALL; Geol. Rep. Ohio, Palæont., Vol. II., p. 126, Plate 6, Figs. 7 to 9.

1881. *Periechocrinus ornatus* — W. and SP.; Revision Palæocr., Part II., p. 132.

Syn. *Succocrinus Benedicti* — S. A. MILLER; 1892, Adv. Sheets 18th Rep. Geol. Surv. Indiana, p. 29, Plate 5, Figs. 1 and 2.

A smaller species than the preceding one. Calyx obovate; the dorsal cup elongate urn-shaped, obscurely pentangular in the upper portions, the rays at the arm bases widely separated, especially upon the posterior side. Plates highly elevated, subconical, with deeply channeled sutures; the surface covered with coarse rugosities or irregular protuberances, meeting in the centre of the plates, and passing out to the edges.

Basals rather large, forming a moderately spreading cup. Radials and costals higher than wide, gradually decreasing in size; the former considerably larger than the costals. Distichals free from above the third plate. Arm structure unknown. Interbranchials in five rows; the first plate as large as the first costal; there are two in the second range, and five in the three

upper ones together, the latter meeting the interambulacral pieces. Interbrachials apparently three. Ventral disk rather depressed near the outer margin; the central portions gradually rising to a good-sized anal tube, composed of moderately large, convex plates similar to those forming the tegmen.

Horizon and Locality. — Niagara group; Yellow Springs, O., and St. Paul, Shelby Co., Ind.

Remarks. — This species departs from the others in having a large anal tube, a character which in other groups has been regarded of generic importance, and we should propose for it a new genus if we were better informed as to the anal structure of the other species.

***Periechocrinus tennesseensis* (HALL).**

Plate L. Fig. 4.

1850. *Saccocrinus tennesseensis* — TROOST MS.

1875. *Saccocrinus tennesseensis* — HALL; Geol. Rep. Ohio, Palæont., Vol. II., p. 125, Plate 6, Fig. 10.

Syn. *Saccocrinus speciosus* — ROEMER (not HALL); Silur. Fauna des Westl. Tenn., p. 42, Plate 3, Figs. 3a, b, c.

Of the type of *P. speciosus* Hall, but the third division of each ray takes place in the calyx and not in the arms; and it has twenty primary arms in place of ten. Dorsal cup elongate obconical, one fourth higher than wide, slightly inflated at two thirds its height. Arm bases conspicuously projecting, deeply depressed between the rays and their main divisions; the depressions of the anal side widest and deepest. Surface of plates smooth, with a faint longitudinal elevation along the radial series, which at the top of the dorsal cup widens to the full width of the arms.

Basals forming a somewhat conical cup. Radials much larger than the costals; the latter considerably narrower, and but little longer than wide. Distichals two, half the size of the preceding axillary, as wide as high. Palmars still smaller, rounded like arm plates. Arms thin, cylindrical, arranged in pairs, biserial from their origin. Interbrachial areas composed of five or six rows; the plates arranged as in the preceding species, including those of the anal side. Ventral disk constructed of a number of polygonal plates without definite arrangement. Anus subcentral.

Horizon and Locality. — Niagara group; Decatur and Perry Cos., Tenn., and Yellow Springs, O.

Remarks. — The type specimen, collected by Dr. Troost, came from De-

catur Co., Tenn., and there is but little doubt that the one described by Roemer, and provisionally referred by him to *Saccocrinus speciosus* Hall (Silur. Fauna West. Tenn., Plate 3, Fig. 3), represents the same species. We have in our collection several specimens from that locality with four arms to each ray, but none with three in the posterior rays, as shown in Roemer's figure, which is said to be a restoration. The specimen described afterwards by Hall is a natural cast in the Ohio State Cabinet.

Periechocrinus Howardi (S. A. MILLER).

1892. *Saccocrinus Howardi* — S. A. MILLER; Adv. Sheets 18th Rep. Geol. Surv., Indiana, p. 30, Plate 5, Figs. 3 and 4.

A small species. Calyx higher than wide, broadly truncated at the base, and but slightly expanding, so as to be almost subcylindrical to near the arm bases, which bend abruptly outward. Plates tumid, without ornamentation; suture lines beveled.

Base short, forming a broad rim, which is squarely truncated at the bottom; its diameter equal to two thirds the greatest width of the cup. Radials more tumid than the other plates, about as wide as long. First costals two thirds the size of the radials; the second much smaller. Distichals three, directed almost at right angles to the axis of the calyx; supporting the free arms. Arm openings ten, arranged in pairs, each pair separated by numerous interrarial plates, which connect with the plates of the tegmen. Interrarial areas composed of two or three large tumid plates, followed by smaller ones. In the type specimen there is but one large plate in the second row at the regular sides, probably the usual two being consolidated. Anal area much wider and somewhat flattened, the plates rising almost vertically. Anal plate followed by 3, 3, and 5 interbrachials; those of the latter row irregularly arranged. Ventral disk almost on a level with the arm bases, only the central part a little convex; composed of numerous small plates without definite arrangement. The anal opening marginal.

Horizon and Locality. — Niagara group; St. Paul, Shelby Co., Ind.

Remarks. — Being unable to obtain the type specimen, our description is made after Miller.

(?) *Periechocrinus Whitei* (HALL).*Plate XLVI. Figs. 1, 2, 3, and Plate LI. Figs. 9, 10.*

1861. *Actinocrinus* (*Megistocrinus*) *Whitei*—HALL; Prelim. Descr. New Crin., p. 2, and Bost. Journ. Nat. Hist., p. 271.
 1873. *Megistocrinus* (*Saccocrinus*) *Whitei*—MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 397, Plate 6, Figs. 1a, b, c.
 1877. *Megistocrinus Whitei*—S. A. MILLER; Amer. Palæoz. Foss., p. 83.
 1881. *Periechocrinus Whitei*—W. and SP.; Revision Palæocr., Part II., p. 133; and Whitfield; Amer. Mus. Nat. Hist., 1893, Vol. I., p. 27, Plate 2, Fig. 29.
 Syn. *Actinocrinus* (*Pradocrinus*) *amplus*—MEEK and WORTHEN; 1861, Proc. Acad. Nat. Sci. Phila., p. 133, also 1868, Geol. Rep. Illinois, Vol. III., p. 470, Plate 16, Fig. 2.
 Syn. *Actinocrinus amplus*—S. A. MILLER; Amer. Palæoz. Foss., p. 66.
 Syn. *Periechocrinus amplus*—W. and SP.; Revision Palæocr., Part II., p. 131.

Calyx depressed bell-shaped, height and greatest width nearly equal; tegmen flattened or depressed convex; plates thin, and without ornamentation; radial ridge but faintly indicated.

Basals forming a shallow basin, abruptly truncated at the bottom for the reception of the column; the latter occupying two thirds the diameter of the base. Radials large, length and width subequal, their upper lateral faces shorter than the corresponding lower ones. First costals scarcely more than half the size of the radials, proportionally a little longer, and hexangular; second costals much smaller than the first, and pentangular. The latter support four distichals, which according to the age of the specimen are either all fixed or in part free. The distichals short, even the first which is twice as long as the succeeding ones. Arm facets projecting, arranged in pairs, the spaces between the rays twice as wide as those between their main divisions. Arms long, gradually decreasing in size upwards, very delicate at the top, biserial above the first to the third distichal. Pinnules long, closely packed and rather stout; their joints twice as long as wide. First interbrachial as large as the first costals or larger; supporting two smaller plates in the second range, three in the third, and a number of irregular pieces above. Anal interradius very wide; each one of the three plates resting upon the first anal almost as large as the one plate of the regular sides. They are followed by three smaller pieces, and these in large specimens by as much as twenty or more plates, of which the upper row connects with the plates of the tegmen. The disk plates are small throughout, and closely resemble the interambulacral plates of some *Pentacrinidæ*. Anus excentric, rising but little above the general surface of the tegmen. Column stout, the joints

quite uniform; their upper and lower faces striated at the margin, and smooth in the middle; axial canal of moderate size.

Horizon and Locality. — In the Kinderhook group at Le Grand, Marshall Co., Iowa, and in both divisions of the Burlington group at Burlington and other places.

Remarks. — There can be no doubt that the specimens of the three beds represent one and the same species, although differing considerably in size. In the Kinderhook group the specimens are smaller, and only a single distichal takes part in the calyx, while in the Burlington two or three of them are incorporated, and the specimens have proportionally more interbrachial plates.

(?) *Periechocrinus tenuidiscus* (HALL).

Plate XLVI. Fig. 4, and Plate LI. Fig. 6.

1861. (?) *Actinocrinus tenuidiscus* — HALL; Prelim. Descr. New Crin., p. 14.

1877. *Actinocrinus tenuidiscus* — S. A. MILLER; Catal. Palæoz. Foss., p. 68.

1881. *Periechocrinus tenuidiscus* — W. and SP.; Revision Palæocr., Part II, p. 133.

Closely allied to the preceding species, and perhaps a mere variety of the same. Dorsal cup more compressed, and distinctly rounded, the arm bases less projecting, and the plates ornamented. The plates of the dorsal cup covered by broad, ill-defined ridges passing out from near the middle of the plates to the margins, where they meet the ridges of adjoining plates. The ridges following the brachials more prominent, especially as they approach the arm bases. A similar ridge follows the median line of the anal area. The surface of the plates is beautifully marked by very fine radiating wrinkles; the plates very thin at their outer margins, and but little thicker in the middle.

Basals forming a low hexagonal basin, with a slightly projecting rim at the bottom; the column facet somewhat concave, occupying one half the diameter of the cup. Radials large, nearly as long as wide; the costals considerably smaller, decreasing in size upwards in the same proportions as the radials and first costals. Distichals, so far as observed, two or three in the calyx; the two upper ones curved like arm plates. First interbrachial as large as the first costals, and as wide as long, those of the second row equal to the second costals; the second row has two or three plates, and the succeeding ones three or four. Anal interradius very wide; the first anal plate smaller than the radials; the three plates overlying it as large as the first inter-

brachial of the regular sides; succeeding rows generally containing five plates. Interdistichals one. Structure of tegmen and arms not known.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

MEGISTOCRINUS O. and SHUM.

1852. OWEN and SHUMARD; U. S. Geol. Rep. Iowa, Wisc. and Minn., p. 594.
 1858. HALL; Geol. Rep. Iowa, Vol. I, Part II., p. 479.
 1869. MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 163.
 1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 393.
 1879. ZITTEL; Handb. der Palæont., Vol. I., p. 371.
 1881. W. and SP.; Revision Palæocr., Part II., p. 135 (Proc. Acad. Nat. Sci. Phila., p. 309).
 1890. S. A. MILLER; North Amer. Geol. and Palæont., p. 260.

Specimens generally large; the calyx depressed, wider than high; flattened on the bottom, and sometimes excavated; the plates heavy. Basals three, closely anchylosed and not divisible, forming together a thick hexangular plate, pierced by a large canal. Radials generally spread out horizontally, wider than long, and all hexagonal in outline. Costals of a similar form to the radials, and almost as large. The number of brachials participating in the calyx is quite variable among the species; in some of them the rays are free from above the distichals, while in others palmars, and exceptionally post-palmars, are incorporated. Arms biserial throughout, branching, and gradually diminishing in size upwards. Pinnules small and rarely preserved. The food grooves of the arms covered by two rows of covering plates, bordered on each side by a series of well defined side pieces, which in some species enter the tegmen. Interbrachials numerous and in contact with the interambulacral pieces. Anal area very wide; the three plates of the first interbrachial row large, and followed by several ranges of from four to six pieces. Ventral disk low hemispherical, the orals and radial dome plates often isolated by small perisomic plates, which increase in number with the growth of the individual. Anus excentric, sometimes marginal. Column very large and long, with strong cirri at the distal end; the central canal wide and pentalobate.

Distribution. — This genus appears in America in the Corniferous, survives the Hamilton and Kinderhook groups, and disappears before the close of the Upper Burlington. In Europe it is probably represented by "*Actinocrinus*" *globosus* Phillips, from the Mountain limestone of England.

Type of the genus: *Megistocrinus Evansi*.

Remarks.— We have not been able to trace the type of *Megistocrinus Knappi*, having searched for it in vain in the Knapp collection at New Providence, Ind., and in the Lyon collection; and we omit describing it, as the figures in the Proceed. of the Soc. Nat. Sci. Phila. are somewhat misleading.

The branching of the arms in their biserial state, whereby there are two rows of interlocking joints below the first bifurcation, as it occurs in this genus and in *Periechocrinus* and *Abucocrinus*, is very characteristic of the three genera, which are otherwise well distinguished from each other. This arm structure occurs also in *Actinocrinus* when there is a bifurcation beyond the calyx, and in some of the Rhodocrinidæ.

Megistocrinus Evansi O. and SHUM.

Plate XLVII. Figs. 1a, b, 2a, b, 3, 4a, b, 5a, b, c.

1850. OWEN and SHUMARD; Journ. Acad. Nat. Sci. Phila., Vol. II., p. 68.
 1852. OWEN and SHUMARD; U. S. Geol. Surv. Wisc., Iowa and Minn., p. 594, Plate 5A, Figs. 3a, b.
 1881. W. and SP.; Revision Palæocr., Part II., p. 137.
 Syn. *Actinocrinus brevicornis* — HALL; 1858, Geol. Rep. Iowa, Vol. I., Part II., p. 571, Plate 10, Figs. 4a, b (*Megistocrinus brevicornis* W. and Sp.).
 Syn. *Actinocrinus superlatus* — HALL; 1858, *ibid.*, p. 572.
 Syn. *Actinocrinus minor* — HALL; 1858, *ibid.*, p. 573.
 Syn. *Megistocrinus plenus* — WHITE, 1862, Proceed. Bost. Soc. Nat. Hist., Vol. IX., April number (Author's Ed., p. 16).
 Syn. *Megistocrinus parvirostris* — MEEK and WORTHEN; 1869, Proc. Acad. Nat. Sci. Phila., p. 165, and Geol. Rep. Illinois, Vol. V., p. 396, Plate 6, Fig. 7.

Attaining very large size. Calyx wider than high, truncated to near the top of the radials; basi-radial sutures broadly and deeply channeled; basals more or less depressed, rarely rising beyond the plane of the radials; sides of the dorsal cup evenly spreading to the top of the costals, and more abruptly thence to the arm bases. Plates heavy, a little convex, the surface smooth or slightly corrugated, the suture lines deeply canaliculate.

Basals closely anchylosed; horizontal, rounded off toward the basi-radial sutures, forming a nearly flat hexagon pierced by a large pentalobate canal; the column occupying about one half its diameter. Radials wider than long, all hexagonal in outline; their lower faces parallel with the upper; upper and lower sloping faces about equal. First costals hexagonal, as long as the radials, but somewhat narrower; the second smaller and pentangular. The axillary costal supports at each side two large distichals, followed by palmars, of which the two proximal ones at either side of the axillary are nearly as long as wide, comparatively large, and those of the same ray interlock at

the inner sides. They are succeeded in full grown specimens by two series of plates of the same order, which to the fifth or sixth rows are incorporated into the calyx. There are ten pairs of very large arm openings directed upwards, of which those of the same pair are contiguous, while those of adjoining pairs are placed apart, being separated by well marked depressions. In young specimens, the arms are free above the second distichal, and there are but five pairs of arm openings, which are arranged as the ten in the older ones. Between these two forms there are others of intermediate stages in which, although having as yet but ten openings, these are arranged singly — not in pairs — and their axillary distichals form the uppermost plate of the ray in the calyx. Arms long, rather stout, frequently dichotomizing. Interbrachials in large specimens: 1, 2, 2, 3, 4, 4, 2, with slight variations in the upper rows; interdistichals, 1, 2, 3, 2; anal interradius: 1, 3, 4, 5, 7, and a number of smaller plates above. The smallest specimen under examination has but 1, 2, 2 interbrachials, a single very minute interdistichal, and 3, 4, and 5 plates above the first anal. Tegmen low hemispherical to almost flat, with distinct plications toward the outer margin — corresponding to the rays and their main divisions — and a slight groove at the anal side. Posterior oral highly convex, conical, or even spinous, and sometimes as large as the four others together, from which it is separated by several rather large, tumid plates, and in the larger specimens by very small, irregular, flat pieces of subsequent growth interspersed between the larger ones. The smaller orals and radial dome plates are surrounded by similar plates, which increase in number, as well as in size and convexity, with the size of the specimen. In the smallest examples before us there are five minute, isolated pieces, interposed at the ends of the inter-oral sutures, and the orals are still in contact among themselves and with the radial dome plates by small surfaces. In the next largest specimens, the interposed plates, although yet very small and flat, are united laterally so as to separate the orals, as well as the radial dome plates. In the largest specimens, the interposed plates are not only larger but also convex, and hundreds of secondary disk plates are introduced between them over the whole surface, resembling in form and character the primary ones in their earlier phases. Such pieces are found also in vast numbers near the outer margin, decreasing in size as they approach the arm openings. The radial dome plates — *i. e.* covering pieces — are very irregularly developed, some rays having but a single plate, others four or five, and while some of them are isolated, others are in con-

tact and alternate with one another. Anus at the end of a probosciform protuberance, within the arm regions or a little above or below. Column large and long. In a large specimen it was found preserved to a length of three feet, but evidently was considerably longer; it gradually increased its diameter from 14 mm. at the top to 24 mm. at the distal end. Near the calyx, the nodal joints, which at their edges are rounded and somewhat undulating, project conspicuously over the youngest and those of intermediate growth, but farther down on the stem the latter attain the size of the oldest, and a wider joint always alternates with a narrower one. Toward the distal end all the joints become of the same length and width, their proximal and distal surfaces are covered with fine radiating striæ, and the lines of union are zigzag. Central canal extremely large, occupying one third the diameter of the joint, and obscurely pentalobate. The lower end of the column has not been observed, but from detached parts, which undoubtedly belong to this species, it appears that it was provided for quite a distance with long and stout branches, which were perforated by a canal of elongate form.

Horizon and Locality.—Found in both divisions of the Burlington group up to the white crystalline layers of the upper bed; Burlington, Iowa, and Henderson Co., Ills.

Remarks.—The size of this species is extremely variable. Among the fifty-two specimens under examination, the calyx varies from 5 to 65 mm. in length, and from 7 to 85 mm. in width. As a rule, the specimens from the Upper Burlington division are a shade larger, yet White's type of *Megistocrinus plenus*, the Upper bed form, in the Museum of Comparative Zoölogy, is considerably smaller than the largest specimens from the Lower bed. *M. plenus* was said to differ "by its convex base, prominent basal plates, channeled sutures, and the proportions of the body plates;" but neither one of these distinctions will stand when a large number of specimens are compared. The basals are not prominent in any of them—not even in the type—and the suture lines are not more channeled than they are in specimens from the Lower bed. *Actinocrinus minor*, *A. superlatus*, and *A. brevicornis*, which we have always held to be one species, represent earlier stages in the development of *Megistocrinus Evansi*, as we suggested in the Revision (Part II., p. 138). "*Actinocrinus*" *minor* with fewer anal plates, and the anal aperture much lower on the posterior side, represents the youngest form of the species, and *A. superlatus* and *A. brevicornis* a transition between

the young and the adult. The two latter are said to differ in the number of interbranchials, in their surface markings, and the condition of the posterior oral, whether spinous or not, — characters unreliable for specific separation. *Megistocrinus parvirostris* M. and W., which is comparatively small, and of which the anus is described as located below the arm bases, is the younger stage of "*Megistocrinus plenus*," both coming from the Upper bed. The position of the anus in this species is quite variable, being sometimes below the arm regions not only in the smaller specimens, but frequently also in the larger ones.

This species is interesting for the light it throws upon the growth of the individual. In the smallest, and, as we think, youngest specimens, there are but two arm openings, the brachials being free above the second distichals, and remaining to a large extent in the condition of arm plates. The larger and more mature specimens, with the interbranchials increased to more than twice their previous number, have four arm openings, and the *biseriate* distichals and palmars, the latter as far as to the fifth row, form part of the calyx walls. The tegmen in its earlier form is composed of but few plates, and the orals are in contact among themselves and with the radial dome pieces. Gradually with growth small supplementary pieces were introduced, and between these, which increased in size, were interposed in turn hundreds, and even thousands, of minute secondary pieces, still more increasing the capacity of the calyx, and encroaching upon the ambulacra so as to leave but a few isolated ambulacral plates exposed at the surface.

***Megistocrinus Evansi* var. *crassus* (WHITE).**

1862. WHITE; Proceed. Bost. Soc. Nat. Hist., Vol. IX., p. 17.

1881. W. and Sp.; Revision Palæocr., Part II., p. 137.

Calyx very large, differing from *M. Evansi* in the massiveness of its plates and the greater depression of the base. The radials are formed into high, broad knobs with deep channels along the interrarial and basi-radial sutures, and their surfaces are covered with coarse irregular corrugations. The nodes of the brachials and interbranchials are more conical.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Megistocrinus nobilis W. and Sr.*Plate XLVII. Figs. 6, 7, 8a, b, and Plate LI. Fig. 8.*

1890. W. and Sr.; Geol. Rep. Illinois, Vol. VIII., p. 169, Plate 16, Figs. 6 and 7.

1890. S. A. MILLER; North Amer. Geol. and Palæont., p. 260.

Syn. *Megistocrinus parvus* W. and Sr.; Geol. Rep. Illinois, Vol. VIII., p. 171.

Somewhat smaller than the preceding species. Calyx subglobose, nearly as wide as high; the tegmen depressed hemispherical. Dorsal cup to the middle of the radials slightly flattened, but still convex; the costals and proximal distichals gently curving; the higher brachials bending outward and curved transversely, forming ten lobes around the calyx, corresponding to the main divisions of the rays. Plates heavy, a little concave; suture lines somewhat grooved, those between the basals and radials deeper than the others.

Basals small, forming a hexagon, of which only a narrow rim is visible beyond the column. Radials hexangular in outline, a little wider than long, the upper and lower lateral faces of equal length. First costals as large as the radials; the two posterior ones pentangular, the others hexangular. Second costals smaller than the first, and pentangular. First distichals as large as the axillary costal; those of the second row somewhat smaller; succeeding distichals biserial, the plates alternating, and decreasing rapidly in length upward. There are four plates in one series and five in the other, both followed by two series of short transverse palmars, which to the third plate take part in the calyx, and bifurcate again above the fifth or sixth. Arm facets arranged in ten pairs, large, and directed upwards. Arms short in proportion to the size of the calyx, bifurcating three or four times, the tips infolding; they are robust at their bases, but diminish in size with each bifurcation, and are composed of moderately short pieces. Pinnules short and rarely preserved. Regular interbrachials in five or six ranges: 1, 2, 2, 3, 3, 2, with slight variations. Interdistichals in three or four rows; the first generally resting upon the second distichals, rarely upon the first. The first anal plate longer than the radials; the three plates above as large as the first interbrachial of the other sides; followed by four or five plates, and these by numerous others of indefinite arrangement. Ventral disk from almost flat to moderately convex; the plates flat, of almost uniform size and irregular arrangement. The orals, if represented at all, indeterminable,

as also the ambulacral plates, except near the outer margins of the tegmen, where well defined covering and side pieces are on a level with the interambulacra; and similar pieces occur along the arms. The covering plates are quite regular in their arrangement, forming a sort of ridge with a row of side pieces at each side. Anus excentric, at the top of a short, rounded or conical protuberance. Column large, giving off heavy branches at the distal end; it increases but little in width, and is composed throughout of alternate thick and thin joints. Central canal moderately large, obscurely pentalobate, and proportionally wider at the lower end.

Horizon and Locality.—Kinderhook group; Le Grand, Marshall Co., Iowa.

Type at Pasadena, California, but authentic specimens are in the collection of Wachsmuth and Springer.

Remarks.—*Megistocrinus parvus* has the same affinities with *M. nobilis* as "*Actinocrinus*" *brevicornis* with *Megistocrinus Evansi*, and we regard it a young stage of that species. The arms are free above the distichals, and it has less interbrachial plates. The specimen, Plate LI., Fig. 8, is somewhat abnormal, having but one costal in two of its rays.

***Megistocrinus latus* (HALL).**

Plate XLVIII. Figs. 3a, b.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 480, Plate I, Figs. 1a, b.

1881. W. and SP.; Revision Palæocr., Part II., p. 138.

A large species. Dorsal cup short, about twice as wide as high, abruptly depressed at the bottom; the sides expanding upwards; arm bases slightly projecting; plates flat and without ornamentation; suture lines grooved.

Basals closely anchylosed, rather large, located at the bottom of an inverted cup, which is a little wider than the column. Radials about as wide as long; their lower ends abruptly curved to form the sides of the basal concavity, the other portions spreading horizontally and constituting the bottom of the calyx. First costals generally longer than the second. Distichals in the antero-lateral rays three, supporting two arms; the other rays have a single axillary, followed by several palmars with four arms to the ray. Interbrachials: 1, 2, 3, 3, and some small pieces between the arm bases. The first anal plate, which is a little narrower than the radials, is succeeded by three plates, and these by numerous irregularly arranged pieces,

which decrease in size upwards. Interdistichals one or two, placed longitudinally. Ventral disk hemispherical; the plates nearly flat and of irregular arrangement; orals and radial dome plates a little larger and convex. Anus subcentral. Column strong, the axial canal large and obtusely pentangular.

Horizon and Locality. — Hamilton group, New Buffalo, Iowa.

Megistocrinus Farnsworthi (WHITE).

Plate XLVIII. Figs. 4a, b.

1876. WHITE; *Proceed. Acad. Nat. Sci. Phila.*, p. 29.

1881. W. and SP.; *Revision Palæocr.*, Part II., p. 138.

Of moderate size. Calyx subglobose, nearly as high as wide; the lower portions of the dorsal cup to the middle of the first costals truncated, the sides almost at right angles with the base, very slightly expanding to the arm bases, the latter somewhat projecting; the plates convex and without ornamentation.

Basal disk proportionally large, slightly projecting; the central part a little excavated for the reception of the column; axial canal rather large and obtusely pentangular. Radials horizontal, smaller than the costals. First costals abruptly curved; the lower end of the plates on a level with the radials, the upper ends vertical. Distichals three in the two antero-lateral rays; in the three other rays but one, which being axillary is succeeded by 2×4 palmars. Arms sixteen, arranged in groups of two and four; the arm bases a little projecting. Interbranchials: 1, 2, 2, 3, followed by several smaller pieces between the arm bases. The first anal plate, which is a little narrower than the radials, succeeded by rows of three, four, and six pieces, with numerous irregularly arranged plates above. Interdistichals two to four, the lower one sometimes touching the costal axillary. Ventral disk high, slightly conical; composed of rather large pieces. Orals completely isolated by supplementary pieces; they are larger than the surrounding plates, but not more prominent. Anus subcentral.

Horizon and Locality. — Hamilton group; Solon, Iowa.

Types in the Museum of the State University at Iowa City.

Megistocrinus depressus (HALL).*Plate XLIX. Figs. 2, 3, and 4a-d.*

1862. HALL; 15th Rep. N. Y. State Cab. Nat. Hist., p. 134.

1881. W. and Sp.; Revision Palæocr., Part II., p. 137.

Syn. *Megistocrinus ontario* HALL, 1862; 15th Rep. N. Y. State Cab., p. 136.

As large as the preceding species. Calyx depressed, wider than high; the dorsal cup basin-shaped; the bottom part to the middle of the first costals — sometimes higher — flattened but not excavated; the sides slightly expanding to the top of the distichals, thence curving outward and forming a short rim, from which the free arms are given off in pairs. Plates flat or a little concave, thickened around their outer margins, and in well preserved specimens covered by numerous very fine, somewhat irregular striæ, which are more pronounced near the suture lines; the middle of the plates sometimes slightly elevated, and the surface covered with small irregular pustules.

Basals small, only the points of the outer angles visible beyond the column; almost flat, and on a level with the radials; the axial canal large and indistinctly pentagonal. Distichals from one to three in the calyx. Three of the rays have a single distichal in both divisions, which is axillary and followed by 2×2 short palmars, the other rays two additional distichals and no palmars. Arm openings sixteen, arranged in eight pairs. The median lines of the higher brachials are ornamented with indistinct, longitudinal ridges, covered by similar striæ as the other parts of the plates. Interbrachials: 1, 2, 3, with two or three irregular rows above, which meet the interambulacral plates. First anal plate, which is a little larger than the radials, followed by 3, 4, and 4 pieces, and these by a number of smaller ones. Interdistichals one to three, arranged longitudinally; the rays with four arms generally having three, the others not more than two. Ventral disk depressed-convex; the food grooves marked by ridges, which diverge to the arm bases; the surface is covered by rather large, flat, irregular pieces enclosing the orals and radial dome plates, which are but little larger than the rest of the plates. Posterior oral in contact with the others, central and spiniferous, while the other four are generally flat. Anus excentric.

Horizon and Locality. — Hamilton group; Western New York and Louisville, Ky.

Remarks.—We had for comparison a number of specimens from the American Museum at New York, some of which Prof. Hall had labeled *M. depressus*, others *M. ontario*. These specimens, in our opinion, differ only in the greater or less depression of the calyx from outside pressure, and in the greater convexity of their secondary radial dome plates, which in some specimens are strongly tuberculous, in others almost perfectly flat.

Megistocrinus nodosus (BARRIS).

Plate XLIX. Figs. 5a, b.

1878. BARRIS; *Proceed. Davenport Acad. Nat. Sci.*, Vol. II., p. 285, Plate 11, Fig. 4.
 1885. BARRIS; *ibid.*, Vol. IV., p. 99, Plate 1, Fig. 8 and Plate 2, Fig. 2.
 1891. W. and SP.; *Revision Palæocr.*, Part II., p. 138.

A large species. Dorsal cup broadly urn-shaped, the truncated part embracing basals, radials, and first anal plate, which are in about the same plane; the sides of the cup, which rise from the lower end of the first costals, slightly convex, expanding near the arm bases. Plates without ornamentation; but the costals and the interbrachials of the two proximal rows are somewhat nodose, while the radials are slightly convex, and the distichals and upper interbrachials almost flat.

Basal disk but very little projecting beyond the column, the column facet excavated and surrounded by a well defined circular rim. Radials and costals increasing in width upwards; the radials longer than wide; the costals wider than long. The higher orders of brachials arranged as in the preceding species. Arms sixteen from the calyx; long, slender, bifurcating, and composed of a double series of interlocking pieces. First interbrachial as large as the first costals; followed by three or four rows of two plates each. First anal plate succeeded by 3, 4, 4, and 3 plates. Interdistichals two to three. Tegmen highly convex, somewhat inflated posteriorly, the interrachial and interaxillary spaces deeply grooved from half way down to the arm regions; the posterior groove broadest and deepest; the surface paved by numerous irregular pieces, among which the orals are larger, subspinous, and not in contact; the radial dome plates strongly nodose. Anus subcentral. Column large.

Horizon and Locality.—Hamilton group; Davenport, Iowa, and Alpena, Mich.

Types in the Museum of the Davenport Academy of Natural Sciences.

Megistocrinus multidecoratus (BARRIS).*Plate XLIX. Fig. 6.*

1885. *Megistocrinus nodosus*, var. *multidecoratus* — BARRIS; Proceed. Davenport Acad. Nat. Sci., Vol. IV. p. 100, Plate II., Figs. 3 and 4.

1885. W. and Sp.; Revision Palæocr., Part III., p. 113.

This species agrees in the general form and the arrangement of the plates closely with *M. nodosus*, but differs essentially in the extent and character of its ornamentation. The plates, instead of having a single central node, are covered by series of nodes, and these are not restricted to a few plates as in that species, but cover every plate of the calyx. The nodes are as a rule well defined, but of irregular size and without definite arrangement, and they vary in number in different plates; the radials, costals, and first interbrachials have from five to twelve, which are arranged in rows; while the higher brachials seldom have more than two or three at the most. The plates of the tegmen are also highly ornamented, each one bearing a central node, from which rows of smaller nodes radiate to the angles. It may be further stated that in this species the dorsal cup is less flattened at the bottom, the radials are proportionally larger, and the first costals take part in the lateral walls, and not in the truncated lower portions. Number of arms, position of anus, and form and arrangement of orals and radial dome plates as in the preceding species.

Horizon and Locality. — Hamilton group; Alpena, Mich.

Types in the Davenport Academy of Natural Sciences.

Remarks. — We regard this form as a good species, and not a variety of *M. nodosus* as supposed by Barris; the differences are very marked and constant. We examined a large number of specimens of both forms, and experienced no difficulty in distinguishing them promptly.

Megistocrinus rugosus LYON and CASS.*Plate XLVIII. Figs. 6a, b, c.*

1859. LYON and CASS.; Amer. Journ. Sci., Vol. XXVIII., p. 243.

1881. W. and Sp.; Revision Palæocr., Part II., p. 138.

Calyx depressed, its height to the base of the anal tube one third less than its width. Dorsal cup shallow basin-shaped, yet considerably higher than the tegmen, three times as wide as high, truncated to the middle of

the first costals and first interbrachials, then curving abruptly upward, widening a little in the upper part. Surface of plates, except basals and radials, strongly nodose, the nodes cut up by irregular grooves or coarse wrinkles, which give to the species an extremely rugged appearance.

Basals small, flat, disk-like, slightly depressed, only the points of the angles projecting beyond the column; central perforation large and pentalobate. Radials, first costals, and first anal plate hexagonal and of nearly the same size; the second costals pentagonal, hexagonal, or heptagonal, owing to the height of the interbrachials of the second row. Distichals 3×2 in the antero-lateral rays, decreasing in size; the lower one almost as large as the preceding axillary. The three other rays have but one distichal, and 2 or 3×4 fixed palmars, of which the upper one is short and curved like an arm plate. Arm openings sixteen, arranged in groups of two and four; the arm structure not known. Interbrachials: 1, 2, 3, 3, 3. Anal plate followed by rows of 4, 5, and 4 plates, and a few irregular pieces at the arm regions. Ventral disk depressed-subconical; composed of numerous convex pieces; the orals and radial dome plates large and spinous, and all isolated. Anal tube excentric, strong at the base; consisting of slightly elevated pieces with spine-bearing larger ones interspersed. Column unknown.

Horizon and Locality.—Hamilton group (Corniferous), Clark Co., Ind., and Louisville, Ky.

Megistocrinus concavus WACHSMUTH.

Plate XLVIII. Figs. 5a, b, c.

1885. WACHSMUTH; *Proceed. Davenport Acad. Nat. Sci.*, Vol. IV., p. 96, Plate 1, Figs. 5, 6, 7.

1885. W. and Sp.; *Revision Palæocr.*, Part III., p. 112.

A rather aberrant form of the genus. Calyx wider than high, the ventral disk higher than the dorsal cup; the latter very shallow, abruptly depressed to the top of the radials; the first costals spreading horizontally, and forming a wide and deep inverted cup; the second bending abruptly upward so as to place the upper part of the calyx almost at right angles to the truncated lower part. Plates heavy, and except the basals, radials and first anal plate, which are flat or a little concave, produced into broad, very prominent knobs.

Basals of medium size, forming a hexagonal disk, which occupies the bottom of the concavity. Radials comparatively small, slightly bending upwards, and constituting together with the lower margins of the first costals

the sides of the inverted cup. Costals large, their knobs very prominent, and arranged with those of the first interbrachials into a circle, which surrounds the concavity. Distichals rather large, consisting in the antero-lateral rays of two or three plates, which form the bases of two primary arms; the three other rays have a single plate, which is axillary and supports two palmar from each side and two arms, thus making sixteen primary arms to the species. The arms are not preserved in the specimens, but, to judge from the size of their facets, were moderately stout. Interbrachials disposed in rows of one, two, and three pieces, so arranged as to form, together with the first and second costals, respectively, two well defined circlets of plates around the radials. Anal interradius considerably wider, and made up of a greater number and smaller plates. Ventral disk highly elevated, sub-conical; the orals and radial dome plates larger than the surrounding plates, and extended into short spines; the surrounding plates tuberculous. Anus almost central. Column of medium size; the axial canal wide and obtusely pentangular.

Horizon and Locality. — Hamilton group; Alpena, Mich.

Types in the Museum of the Davenport Academy, and in the collection of Wachsmuth and Springer.

Megistocrinus spinosulus LYON.

Plate XLVIII. Figs. 1a, b, c, and 2.

1861. LYON; Proceed. Acad. Nat. Sci. Phila., p. 413, Plate 4, Figs. 7a, b.

1881. W. and SE.; Revision Palæoec., Part II., p. 138.

Syn. *Megistocrinus pileatus* — S. A. MILLER, 1879; Cincin. Soc. Nat. Hist., Vol. II., p. 114, Plate 10, Figs. 1a, b.

Of the type of *M. rugosus*, but having eight arm openings to the ray, which are arranged in a continuous row around the calyx, and not in groups; the basals slightly projecting instead of concave, the radials more depressed, and the anal tube more excentric. Calyx short in proportion to its width, which at the arm bases is almost twice its height; truncated to the middle of the second costals. The latter plates, and the interbrachials of the second row, are extended into very conspicuous tubercles, and somewhat shorter tubercles mark the first distichals and the interbrachials of the third row; all other plates above and below are slightly convex, except the radials, which are a little concave. The sides of the dorsal cup stand almost at right angles to the base, expanding slightly to the arm bases. Ventral disk low, a little convex, somewhat bulging at the posterior side.

Basals very small, slightly projecting laterally, and notched at the sutures, the column facet depressed and surrounded by a circular elevated rim. Radials generally wider than the first anal plate, forming a shallow depression; the calyx resting upon the first costals and first interradials. Costals larger than the radials, about as wide as long. Distichals axillary, as large as, or larger than, the second costals; followed by a row of axillary palmars, and these by a row of post-palmars, which are directed outward, and support eight primary arms to the ray, forming an uninterrupted line around the calyx. Interbrachials: 1, 2, 2, 2, 1, 1, the two upper very small. The plates of the first row, together with the first costals, forming a circlet, around which another circlet is formed by the second row of interradials and second costals. Anal interradius wider; the first anal supports three plates, which are a little narrower than the single plate at the other sides, and there are 4, 5, 3, 2 and 2 pieces above. Interdistichals two, arranged longitudinally. Tegmen composed of a great number of irregular pieces. Orals not in contact, somewhat larger than surrounding plates, but not otherwise distinguished; placed between the centre and margin of the tegmen. Anus more excentric than in any other Devonian *Megistocrinus*, with the possible exception of *M. abnormis*. Column unknown.

Horizon and Locality. — Hamilton group; Louisville, Ky., and Columbus, O.

Types in the Lyon collection at Jeffersonville, Ind.

Remarks. — This species differs from all others of this genus in having eight primary arms, and in not having them distributed in groups. It has the third bifurcation in the calyx, which in other species takes place in the free arms.

Miller's *Megistocrinus pileatus* from Columbus, O., we take to be identical with this species. That his specimen has but six and seven arm openings in the posterior rays, while others have eight, proves nothing to the contrary; the specimen very probably was not quite mature, and represents a transition between our still younger specimen from the same locality with only five and six arm openings to the ray (Plate XLVIII., Fig. 2), and the larger Louisville specimen (Plate XLVIII., Figs. 1a, b, c) with eight primary arms all around.

(?) *Megistocrinus abnormis* (LYON).

Plate XLIX, Figs. 1a, b, c.

1857. *Actinocrinus abnormis* — LYON; Geol. Rep. Ky., Vol. III., p. 479, Plate 4, Figs. 1, 1a, b.1865. *Megistocrinus abnormis* — SHUMARD; Catal. Palæoz. Foss. N. Amer., p. 380.1881. *Megistocrinus abnormis* — W. and SP.; Revision Palæocr., Part II., p. 137.

This species is remarkable for the large lobes at the arm regions, which give to the calyx a distinctly pentalobate outline, with deep interrarial notches. Dorsal cup saucer-shaped, a little flattened at the bottom; the plates thin, flat or slightly concave, and devoid of ornamentation.

Basals in the same plane with the radials, forming a flat hexagonal disk, of which only a narrow margin is visible beyond the column; central canal large and obtusely pentangular. Radials and costals nearly of equal size. Distichals 3×2 in the two antero-lateral rays, supporting the arms; the three other rays have an axillary in each division and 2×4 palmars. Primary arms sixteen; arranged: $\frac{1}{4}, \frac{1}{4}$. Interbrachials: 1, 2, 3, 3, 3; the first as large as the radials; those of the second row about the same size as the distichals; the plates of the third row considerably smaller; the middle pieces of the fourth row often located in the tegmen. Interdistichals one or two; there are generally two in rays with four arms, and the lower one rests upon the truncated middle part of the preceding axillary, but where there is but one it occupies the notch between the first distichals. Anal interradius extremely wide and somewhat flattened; the first anal, which is fully as large as the radials, often supports four plates in the first row, and five to seven in the second and third. Tegmen highly convex, composed of medium sized, irregular, flat pieces, the ambulacra marked by ridges, and the interambulacral spaces by depressions. Orals in contact; the posterior one and the radial dome plates strongly tuberculous or subspinous, forming six conspicuous prominences upon the surface. Anus located a little above the arm bases, opening out through the flat surface of the tegmen.

Horizon and Locality. — Corniferous; Louisville, Ky., Clarke Co., Ind., and Marian Co., Ky. Very abundant in some localities, but good specimens quite rare.

Types in the Lyon collection.

Remarks. — This is not a typical *Megistocrinus*, and we have referred it with much hesitation to that genus. It departs from the typical form in the wide and deep depressions at the arm regions, in the flattening of the anal

area, and in the form and position of the anus, in all of which it resembles *Aorocrinus*. Lyon's type is in an abnormal condition, and we have figured other specimens in place of it. It has but four arm-bearing rays, the postero-lateral ray apparently having been injured during the life of the Crinoid, and the space from the first axillary up being filled by abnormal growth. Besides the left antero-lateral ray has four in place of two primary arms. Whether the arms of this species are branching is not known.

GENNÆOCRINUS W. and Sp.

1881. W. and Sp.; Revision Palæocr., Part II., p. 160 (Proceed. Acad. Nat. Sci. Phila., p. 334).
 1891. S. A. MILLER; North Amer. Geol. and Palæont., p. 247.
 Syn. *Actinocrinus* (in part).

Calyx distinctly lobed; the interradial spaces extremely wide, and deeply indented at the arm regions. Plates thin, their surfaces ornamented with radiating striæ. Basals three, small; the axial canal large and pentalobate. Radials and costals of similar form, but decreasing in size upwards; the first costal hexagonal, the second heptagonal. The branching of the rays above the distichals is from alternate sides, the second plate of the two main divisions giving off at one side an arm, at the other brachials of a higher order, the last axillary supporting two arms. The different rays have the same number of arms, which is eight, so far as observed. Interbrachials quite numerous, and the upper ones in contact with the interambulacrals; the first is followed by two or three in the second row — which are larger than usual in the Batocrinidæ — and these by three or four smaller ones. The first anal plate supports a second, which has an interbrachial at each side, and there are several rows of four or more plates above. The tegmen is composed of rather small plates, and rises but little above the dorsal cup; the surface is undulated, being grooved and indented interradially, and distinctly raised all along the food grooves, which are covered by two rows of alternate pieces. Orals proportionally small, the posterior one a little the largest. There is no anal tube, the anus being represented by a small, excentric opening, passing out directly through the tegmen.

Distribution. — Restricted to the Hamilton group of America.

Type of the genus. — *Gennæocrinus kentuckiensis* (Shumard).

Remarks. — This genus, in the branching of the rays, grouping of the arms, form of the tegmen, and in the simplicity and position of the anus,

closely resembles *Physetocrinus*, but that, having no anal plate in the first interbrachial row, is an *Actinocrinoid*.

***Gennæocrinus kentuckiensis* (SHUMARD).**

Plate XXXIV. Figs. 11, 12, 13.

1866. *Actinocrinus kentuckiensis* — SHUMARD; Trans. Acad. Sci. St. Louis, Vol. II., p. 345.
 1881. *Gennæocrinus kentuckiensis* — W. and SP.; Revision Palæocr., Part II., p. 161.
 Syn. *Actinocrinus cornigerus* LYON and CASSEDAY, 1859 (not HALL, 1858); Amer. Journ. Sci. (n. series), Vol. XXVIII., p. 238.
 Syn. *Actinocrinus nyssa* HALL, 1862; 15th Rep. N. Y. State Cab. Albany, p. 129.

Of medium size. Calyx wider than high, decidedly lobed at the arm regions, and the arms given off in clusters. Dorsal cup semiglobose; the surface covered with well-defined striæ proceeding from the centre of the plates to their margins. There is a ridge to each face of the plates, and another to each angle, which meet with similar ridges from adjoining plates, and form with them all sorts of triangles. The ridges following the rays increase in prominence as they approach the distichals, and attain at the arm bases almost the width of the arms.

Basals very short, slightly projecting laterally, forming a thin trilobate rim, which is flat at the bottom. Radials and costals as long as wide, decreasing rapidly in size upward; the second costals less than half the size of the radials. Distichals 2×10 , comparatively small, wider than long; the second ones axillary, supporting 2×4 palmars, of which the two of the outer sides are followed by one arm, the two inner ones by two arms, the first plate taking part in the calyx. There are eight arms to each ray, in close contact; while those of different rays are far apart. Whether there is any branching in the free arms is not known. Interbrachials: 1, 2, 4 (sometimes 1, 3, 4); succeeded by one or two rows of smaller pieces, of which the upper interlock with the interambulacral plates. The first anal piece supports three large plates in the first row, five in the second, and five or more in the third. Interdistichals three in two rows. Ventral disk depressed-convex; the interambulacral plates together with the interbrachials form wide and deep recesses around the calyx, while the radial portions project conspicuously upward and outward. All plates of the tegmen of nearly uniform size, and each one covered with a small central tubercle. Orals comparatively small, even the posterior one, which is central, being but little larger than the other plates. Ambulacra covered by two rows of alternating

pieces, with a larger one at each bifurcation. Anus located at midway between the summit and the periphery. Column occupying two thirds the width of the base; axial canal large and pentalobate.

Horizon and Locality.—Hamilton group, Louisville, Ky.

Types in the Knapp collection at New Providence, Ind.

Remarks.—S. A. Miller, in his North American Geology and Palæontology, undertakes to reinstate Lyon's prior name *Actinocrinus cornigerus*, which he changes into *Gennæocrinus cornigerus*. The species was originally described as *Actinocrinus cornigerus*, which Shumard, finding the name preoccupied by Hall, changed into *Actinocrinus kentuckiensis*, by which it is labeled in most of the collections. That the species was referred afterwards to a different genus, does not restore the former name.

***Gennæocrinus eucharis* (HALL).**

Plate XXXIV. Fig. 14.

1862. *Actinocrinus eucharis* — HALL; 15th Rep. N. Y. State Cab. Nat. Hist., p. 130.

1881. *Gennæocrinus eucharis* — W. and SP.; Revision Palæocr., Part II., p. 161 (Proceed. Acad. Nat. Sci. Phila., p. 335).

We were unable to obtain for examination typical specimens of this species, but from the description it appears to us that this form is very closely allied to *Gennæocrinus kentuckiensis*, with which it agrees in the form of the base, arrangement of the brachials, and the number of arms. According to Hall, it is said to differ somewhat in the ornamentation. The ridges which traverse the ray form a sharp carina, with strong nodes on the first costals; while on the centres of all the other plates there are low angular nodes. Hall notices also a slight difference in the form of the dorsal cup, but this is not borne out by the description. We are inclined to regard this species as identical with the preceding one.

Horizon and Locality.—Shales of the Hamilton group, Western New York.

Type in the New York State collection at Albany.

ACTINOCRINIDÆ (ROEMER).

(Emended and restricted by W. and Sp.).

MONOCYCLIC. THE LOWER BRACHIALS WITH WELL DEFINED INTERBRACHIALS BETWEEN THEM, FORMING AN IMPORTANT PART OF THE DORSAL CUP. RADIALS IN CONTACT EXCEPT AT THE POSTERIOR SIDE, WHERE THEY ARE SEPARATED BY A HEXAGONAL ANAL PLATE, WHICH IS FOLLOWED BY TWO INTERBRACHIALS WITHOUT A SECOND ANAL. BASALS FORMING A HEXAGON.

Analysis of the Genera.

Basals 3, equal. Arms biserial, branching alternately from the main divisions of the rays.

A. ANUS AT THE END OF A TUBE.

1. *Interbranchials connected with the interambulacra.*

a. *Calyx lobed, interradial spaces depressed.*

Anal tube long, central. The branching in the calyx above the distichals at alternate sides from every second or third plate. Bifurcations of the free arms, if any, at long intervals *Actinocrinus.*

Rays produced into arm-like tubular extensions, rising to the full height of the crown, giving off arms from alternate sides *Steganoocrinus.*

Anal tube short, excentric. Ventral disk largely predominating over the dorsal cup. Rays widely separated. Arms heavy, generally bifurcating in the free state, the branches divergent *Amphoroocrinus.*

2. *Interbranchials not connected with the interambulacra.*

a. *Calyx not lobed, arms about equidistant, given off in a more or less continuous ring around the calyx; anal tube long, central. Bifurcations beyond the costals from every brachial in the calyx; arms simple.*

Arms directed upward. Ventral disk conical, gradually passing into the tube *Cactocrinus.*

Arms very numerous, their lower portions directed outward, incorporated into the calyx, and forming a broad, flanging, continuous rim *Teleioocrinus.*

B. ANUS WITHOUT A TUBE.

a. *All bifurcations in the calyx given off from the first brachial of successive orders.*

Interbranchials connected with the interambulacra; interspaces between the rays and their subdivisions channeled; arms arranged in groups; ventral disk hemispheric, anus excentric *Physetocrinus.*

Interbrachials not connected with the interambulacra; brachials from the distichals or palmars up extended into a broad, flanging rim as in *Teleocrinus*; arms very numerous; ventral disk low, composed throughout of very small, irregular pieces; anus subcentral . . . *Strotocrinus*.

Geological and Geographical Distribution.

Number of known species.

(Open figures indicate American; those marked (), European.)

FORMATION.			ACTINOCRINIDÆ.						
General.	American.	Approximate European Equivalents.	Actinocrinus.	Steganoocrinus.	Amphorocrinus.	Physetocrinus.	Cactocrinus.	Teleocrinus.	Strotocrinus.
Carboniferous.	Keokuk.	Mountain Limestone.	5						
	Upper Burlington.		6 (15)	1	(3)	3 (?)	1 (?)	5	2
	Lower Burlington.		4	3	2	3	16	1	
	Kinderhook. Waverly. Chouteau.		3	1	1		3		
	Total species 78	60 (18)	18 (15)	5	3 (3)	6 (?)	20 (?)	6	2

NOTE.—There are many synonyms among the forms described by de Koninck and other European writers under *Actinocrinus*; others will have to be referred to different genera.

Remarks.—The relations of the Actinocrinidæ and Batocrinidæ with other Camerata, and the distinctions between these two families, have been sufficiently pointed out in connection with the Batocrinidæ. The absence of an anal plate between the two interbrachials of the first row, and the alternate mode of bifurcation of the arms, will always distinguish an Actinocrinoid from a Batocrinoid.

The Actinocrinidæ were a short lived family, appearing first in the Waverly group, and culminating in the large and striking forms of the

Keokuk group, beyond which no vestige of them has been seen. There are about sixty American species, and perhaps twenty from Europe, where it occurs also only in the Mountain Limestone.

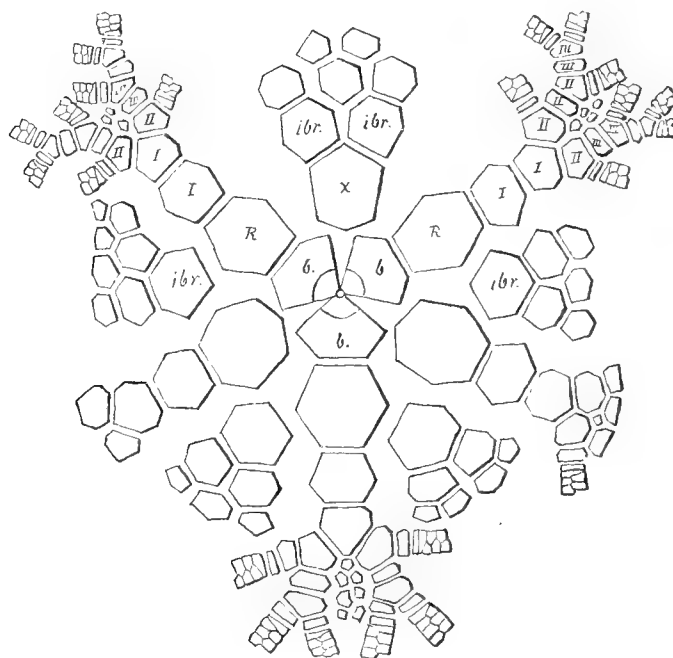


Fig. 19. *Actinocrinus*.

(Explanation of the letters as in Fig. 12.)

ACTINOCRINUS J. S. MILLER.

(Restricted.)

- 1821. J. S. MILLER; a History of the Crinoidea, p. 94.
- 1844. MCCOY; Synops. Carb. Foss. Ireland, p. 181.
- 1844. DE KONINCK; Description Anim. Foss., p. 49.
- 1853. DE KON. and LE HON; Recher. Crin. Terr. Carb. Belgique, p. 123.
- 1855. F. ROEMER; Lethæa Geogn. (Ausg. 3), Jahrg. XIX., p. 246.
- 1857. PICTET; Traité de Paléont., Vol. IV., p. 323.
- 1866. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 147.
- 1873. MEEK and WORTHEN; *ibid.*, Vol. V., p. 341.
- 1878. ZITTEL; Handb. d. Palæontologie, Vol. I., p. 369.
- 1881. W. and SP.; Revision Palæocr., Part II., p. 138 (Proceed. Acad. Nat. Sci. Phila., p. 312).
- 1889. S. A. MILLER; N. A. Geol. and Palæont., p. 216.
- Syn. *Blairocrinus* S. A. MILLER; Adv. Sheets 17th Rep. Ind., p. 69.

Calyx distinctly lobed at the arm regions, the higher orders of brachials forming, together with the ambulacral plates overlying them, five more or less prominent calicular extensions, or brachial lobes, from the two divisions of which the free arms are given off by alternate bifurcation from every second or third plate. The plates of the dorsal cup are ornamented by radiating ridges, which often meet in a node. Basals three, rather large, forming a well defined cup. Radials larger than any of the succeeding plates. Costals two, the first hexangular — exceptionally quadrangular. Distichals all axillary; supporting at their outer side an arm, at the inner from two to three palmars. The succeeding bifurcations take place in a similar manner; each successive order of brachials consists of two or three plates, of which each axillary supports an arm at one side, and two or three post-palmars — according to species — at the other, and so on to the last bifurcation in the calyx, which gives origin to two arms. When there are only four arms to the ray, the last bifurcation is on the distichals, and there is of course no alternation. The arms are given off alternately from opposite sides in almost the same way as the pinnules from an arm with a succession of syzygies; but in *Actinocrinus* the sides of the proximal arm plates are suturally united with the plates which support the succeeding order of brachials. Arms biserial, and frequently branching once or twice after becoming free; the pinnules long, and their proximal joints armed with a small hook, projecting from the middle of the plates. The interbrachial spaces on approaching the arm regions are widely and deeply depressed; they are occupied by numerous plates, which meet with the interambulacral pieces above, and in some species take part in the formation of the brachial extensions. The anal side is the widest, containing one large plate in line with the radials, which is followed by two interbrachials; the anus is located at the distal end of a strong tube, which rises abruptly from the summit of the tegmen. Orals rather small and excentric. The ambulacral plates either consist of two rows of large covering pieces, which pass out from between the orals and follow the branching of the food grooves, or are represented by large single plates of a first and second order, succeeded by small covering pieces, which meet with those of the free arms. Column round, the axial canal small and pentangular.

Distribution. — Restricted to the lower part of the Subcarboniferous or Mountain limestone. In America it makes its appearance in the Waverly group, where it is represented, so far as known, by a single species; it reached

its culmination in the Upper Burlington limestone and Keokuk group, where it became extinct, being the last survivor of the family. In Europe it is represented at Tournay, Belgium, in the Yorkshire regions of England, and at Waterford, Ireland; but no trace of it has been found in the higher Carboniferous rocks of Scotland or Russia.

Remarks.—The genus *Actinocrinus* was made by the earlier writers on Crinoids a receptacle for all—or nearly all—Camerata with a monocyclic base, and in which an anal plate was introduced within the radial ring. This accounts for the fact that the number of species referred to it reaches nearly three hundred. The first departure from this rule was made by Austin in 1843, who introduced the genera *Amphoracrinus* and *Periechoocrinus*; and although his descriptions were meagre and partly incorrect, he gave well known types for both forms, so that they could be readily identified. Owen and Shumard followed in 1852 with *Megistocrinus*, and F. Roemer in 1854 with *Dorycrinus*. In the same year Casseday proposed the genus *Batocrinus*, and in 1859, in company with Lyon, *Eretmocrinus*. But all these genera, with the exception of *Megistocrinus*, were ignored by Hall, who from 1859 to 1861 described a great number of new species of this group. A more important step toward a better understanding of this group was taken by Meek and Worthen, who not only accepted the genera theretofore proposed, but introduced three new ones, viz., *Steganoocrinus* and *Strotocrinus* in 1866, and *Physetocrinus* in 1869, which also are now generally accepted. Afterwards we proposed the genera *Gemmæocrinus* and *Teleioocrinus*, and in 1881 the number of species retained under *Actinocrinus*, after deducting numerous synonyms, was reduced to less than fifty. But even these species were susceptible of division into two sections, as already pointed out in 1866 by Meek and Worthen, viz.,

- A*—species in which the higher brachials, sometimes from the second costals up, are grouped together, so as to form five protuberant lobes, from which the arms are given off from alternate sides.
- B*—species in which the arm bases are arranged in a continuous series around the calyx, *i. e.*, the interbrachials are separated from the interambulacra by the arm-bearing brachials.

These differences we regard as amply sufficient for generic separation. In addition to them there is a constant difference in the number of brachials beyond the costals,—the higher orders of brachials in all species of section *A* consisting of two or three plates, while each such order in those of sec-

tion *B* is composed of a single plate. In this respect the genus *Actinocrinus*, as now restricted to the species of section *A*, differs from all the other genera of the family, one or two species of *Steganoocrinus* excepted.

A consultation of J. S. Miller's Natural History of the Crinoidea, p. 94, shows clearly that his description applies only to section *A*. He says: "When the arms deprived of their fingers project laterally from the subglobose body at the summit of the column, they bear some resemblance to the rays or spokes fixed in the nave of a wheel." This is quite characteristic of the typical species *Actinocrinus triacontadactylus*, and there cannot be the least doubt as to which group should retain the name. For the species of section *B* we propose elsewhere the genus *Cactocrinus*.

Actinocrinus urna, and *A. Humboldti* Troost, are catalogue names. *A. viaticus* White, which is probably closely allied to *A. tenuisculptus*, is not sufficiently well preserved for description. S. A. Miller's new genus *Blairocrinus* is identical with *Actinocrinus* as now restricted. His *Actinocrinus sedaliensis* is described from a very imperfect specimen, and the casts which he refers to that species very probably belong to a different species.

***Actinocrinus multiradiatus* SHUMARD.**

Plate LII. Figs. 3, 4a, b, 5 and 6.

1857. SHUMARD; Trans. Acad. Sci. St. Louis, Vol. I., p. 75, Plate 1, Fig. 5.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 579, Plate 10, Fig. 9.

1881. W. and SP.; Revision Palæocr., Part II., p. 144.

Calyx of medium size, distinctly lobed from a summit or basal aspect. Dorsal cup to the top of the first costals slightly convex, and one fourth to one third higher than from there to the base of the anal tube; the second costals curving abruptly outward. Distichals and palmars horizontal and rounded on the back. They form, together with the plates of the tegmen overlying them, brachial extensions of the calyx; while the interradiar plates between them follow the general curvature of the calyx. Plates of the cup highly ornamented with strong, somewhat undulating ridges, which in sets of from one to four run from near the middle of the plates to the outer margins, where, crossing the sutures, they unite with those from adjoining pieces, and form a number of sets of from two to three concentric triangles. The radials generally have above the centre of the plates a transverse node, from which four prominent ridges proceed to the basals; three

others pass out to the costals and first interbrachials, and from one to three to the other plates; but only those of the middle series are continuous, the two at the sides which form the inner triangles, when present at all, being interrupted and less distinct.

Basals large, forming a broad cup, with rapidly expanding sides; the lower margins projecting over the top of the column, somewhat thickened, and slightly notched at the sutures; the axial canal sharply pentangular. Radials large, longer than wide, the sloping upper faces much smaller than the lateral ones. First costals nearly as long as wide, scarcely half the size of the radials, and hexangular; the second costals from one third to one half smaller than the first. Distichals small, twice as wide as long, axillary; their sloping outer faces support an arm, which becomes free from the second plate, the inner faces two palmars (rarely one or three), of which the upper is axillary and gives off a single arm at one side, at the other post-palmars and two arms. Arms forty, of moderate size, simple throughout, slightly tapering, and somewhat flattened toward the extremities; the plates transversely angular. Pinnules long, their two or three proximal joints covered with small hooks. First interbrachials a little larger than the first costals, supporting two plates, followed by four, of which the two lower are in part interambulacral, and the upper ones touch the orals. Occasionally there are two additional plates between those of the second and third rows. Anal interradius very wide; the anal plate succeeded by two plates in the first, three in the second, and five in the third row; those of the latter, which occupy the equatorial zone, are followed by irregular pieces in the tegmen. Tegmen very short; the plates moderately large, slightly convex, their surfaces rugose. Orals comparatively small, especially the posterior one, which is smaller than the others, and is placed at the side of the anal tube. Tube nearly central, long, heavy throughout, and frequently curving; the plates sharply nodose and transversely arranged. The ambulacral plates, covering the calycine extensions, decrease in size outward, and are immovable; those of the first and second orders consist of large single pieces, but those of the higher orders of two rows of plates. Column proportionally small, composed in the upper part of thicker and thinner joints, the former widest at the top; but at 50 mm. from the calyx all joints have nearly the same dimensions.

Horizon and Locality. — Upper Burlington limestone, Burlington, Iowa, Quincy, Ills., Hannibal, Mo., and other places.

Actinocrinus lobatus HALL (not WORTHEN).

Plate LII. Figs. 1a, b, and Plate LIV. Fig. 3, and Plate LV. Figs. 1a, b.

1860. HALL; Suppl. Geol. Rep. Iowa, p. 51.

1881. W. and SP.; Revision Palæocr., Part II., p. 144.

(?) Syn. *Actinocrinus unicarinatus* — HALL; Suppl. Geol. Rep. Iowa, 1860, p. 48.

Larger than the preceding species; the lobes of the calyx more prominent; the interradian spaces deeper, and formed into pitlike depressions, which extend from the upper part of the first interbrachial to near the orals, reducing the width of the tegmen, with the brachial lobes removed, to the diameter of the dorsal cup at the radials. The dorsal cup rises moderately to the top of the first costals, above which the brachials take an almost horizontal position to the bases of the free arms. The lobes are narrower at the proximal than at the distal end, and at the back of the costals distinctly angular, their sides bending abruptly upward to meet the small interbrachial pieces interposed between them. In the lower part of the calyx, below the lobes, the plates are slightly tumid, having small central nodes, of which those upon the radials and costals are most prominent and transversely arranged. From the nodes, sets of parallel ridges proceed to the outer margins; but these, although quite distinct between basals and radials, are more or less obscure between the other plates.

Basals proportionally large, forming a broad cup, twice as wide as high, notched at the sutures, and thickened around the lower margins. Radials very large, longer than wide, the upper face narrower than any of the others. Costals small, the two together less than one half the size of the radials; the first as wide as long; the second as wide as the first, but shorter. Distichals nearly one third smaller than the upper costals, all axillary. They support at the outer side an arm, which is free from the second plate; at the inner side three palmars, which give off an arm to the inner side of the ray, and to the outer two post-palmars with two free arms from the axillary. Arms forty (not twenty-five as described by Hall), moderately heavy, and branching in their free state. Interbrachials numerous; the first as large as, or larger than, the first costals; the two of the second row one half smaller; there are other irregular plates overlying them, which meet the orals, and are in part interambulacral. Anal interradius the widest, and the plates still more numerous. The central part of the tegmen is almost flat, and raised but little above the top of the lateral extensions; its plates

convex. Orals separated by perisomic plates, and larger than the surrounding pieces; the posterior one subcentral, wider than high; the others somewhat larger and elongate. Covering pieces of first and second orders irregular, and difficult to distinguish from the superimposed interambulacra, but those of the higher orders are regularly arranged in two rows. Anal tube nearly central.

Horizon and Locality. — Transition bed between the Burlington and Keokuk groups. Pleasant Grove, Iowa, Nauvoo, Ills., and Canton, Washington Co., Ind.

Remarks. — The specimen figured by Worthen as *Actinocrinus lobatus* Hall, in the Geological Report of Illinois, Vol. VIII., Plate XII., Fig. 8, is a small example of *Actinocrinus magnificus* W. and Sp.

***Actinocrinus verrucosus* HALL.**

Plate LII. Figs. 2a, b, c.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 578, Plate 10, Figs. 7a, b.

1881. W. and Sp.; Revision Palæocr., Part II., p. 146.

Syn. *Actinocrinus asterias* MCCHESENEY; Descr. New Spec. of Foss., p. 13, and Trans. Chicago Acad. Sci., Vol. I., p. 9, Plate 5, Fig. 6.

Approaching in size the two preceding species, but differing widely in the proportions of the calyx, the greater convexity of the plates, and their surface markings. Calyx distinctly lobed, its height from the base to the foot of the anal tube about equal to the width at the ends of the brachial extensions. The sides of the dorsal cup spreading uniformly to the top of the first costals, thence abruptly outward, bringing the plates forming the brachial extensions into a strictly horizontal position. The plates between the lobes are raised slightly above the general surface of the plates below, forming a low rim around the upper margins of the dorsal cup, differing in this from the two preceding species, in which this part is impressed, and the brachial appendages are more prominent. Tegmen almost as high as the dorsal cup; pyramidal, rising evenly from the outer margins of the lobes to the summit. Plates of the dorsal cup tumid, and the middle of the radials, first costals, anal plate, and first interbrachials, elevated into a prominent node, which, except on the interbrachials, is transversely disposed. From the nodes of the radials and anal plate sometimes two rounded ridges

pass out to the basals, and single ones to the interbrachials and costals; but these ridges, if present at all, are more or less obscure.

Basals moderately large, forming a low cup, which is deeply notched at the sutures, and thickened at the lower margins so as to form a broad rim, which projects outwards and downwards. Radials generally a little longer than wide. First costals half the size of the radials, a little wider than long; the second one half smaller than the first, and twice as wide as long. Distichals one, quite small, giving off from the outer side an arm, from the inner two palmars. The latter support an arm at the inner side, and two post-palmars with two arms at the outer. Arm facets with transverse, imperforate, articular ridge. The respiratory pores small, and placed so close to the ambulacral openings that the intervening walls are rarely intact. Arms forty, moderately heavy, simple throughout, and biserial from the second or third plate. Regular interbrachials: 1, 2, 4, 5, followed by other plates in the tegmen; those of the third and fourth row placed between the lobes, and in part interambulacral. Anal plate smaller than the radials; followed by 2, 3, 4, or 6 plates, and by numerous smaller pieces in the tegmen. Plates of the tegmen sharply nodose and rather uniform in size, except the lower interambulacral pieces, which are somewhat smaller. Orals and radial dome plates indeterminate. Near the arm bases small covering pieces can be recognized. Anal tube almost central, large and heavy throughout; formed of rather large nodose plates, which are intermingled by small almost flat ones.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa, and Monmouth and Quincy, Ills.

***Actinocrinus scitulus* MEEK and WORTHEN.**

Plate LV. Figs. 5, 6a, b.

1860. M. and W.; Proceed. Acad. Nat. Sci. Phila., p. 386.

1866. M. and W.; Geol. Rep. Illinois, Vol. II., p. 202, Plate 15, Figs. 7a, b.

1881. W. and Sp.; Revision Palæocr., Part II., p. 145.

Syn. *Actinocrinus rusticus* HALL; 1861, Descr. New Spec. of Crin., p. 2.

Syn. *Actinocrinus Sillimani* M. and W.; 1861, Proceed. Acad. Nat. Sci. Phila., p. 134.

Syn. *Actinocrinus Wachsmuthi* WHITE; 1862 (not 1879), Proceed. Bost. Acad. Nat. Sci., Vol. IX., p. 15.

Rather below medium size. In the form of the calyx approaching *A. verrucosus*, but the brachial extensions shorter, the interspaces narrower, and the interbrachials less numerous. Dorsal cup obconical, its

sides expanding regularly from the base to the top of the costals, the higher brachials horizontal. Ventral disk depressed convex, occupying about one third the height of the calyx. Surfaces of plates somewhat variable, but, as a rule, the radials and anal plate strongly nodose, the nodes transversely arranged, covering the whole surface of the plates, and extending obliquely outward. From the sides of these nodes indistinct ridges or angularities pass out to the costals, giving to the section of the cup an obscurely pentangular outline; similar ridges proceed to the basals. The first interbrachials are marked with very prominent rounded tubercles, rising abruptly at the middle of the plates, while the higher interbrachials are nearly flat.

Base short, deeply grooved at the sutures, and notched at the lower margins, presenting three well marked lobes, which, hanging downward, enclose the proximal stem joints. Radials nearly as large as both costals together, and as wide as long. First costals hexangular; the second wider than long, and generally smaller than the first. Succeeding brachials small, exteriorly rounded, with deep longitudinal grooves at the sides. Distichals all axillary, their sloping outer faces giving off an arm, the inner ones of both ray divisions two palmars, and these again an arm from the one side, and two post-palmars from the other, of which the axillary supports two arms. Arms forty (not twenty as supposed by Hall, nor thirty as given by Meek and Worthen); long, rounded, not branching in their free state, and not tapering at the extremities. Interbrachial spaces slightly flattened; they consist at the regular sides of 1, 2, and 4 plates, the latter row on a level with the arm openings, and at the anal side of 2, 3, and 5 pieces. Plates of the tegmen of medium size; the orals, which are slightly the largest and not in contact with each other, placed at some distance from the summit. Ambulacral plates of first and second orders represented by large single plates, those of the higher orders by rows of small covering pieces. Anal tube central, and of moderate size.

Horizon and Locality.—Upper Burlington limestone, Burlington, Iowa, and at the same horizon in Missouri and Illinois.

Types in the (Worthen) Illinois State collection, Springfield.

Actinocrinus pernodosus HALL.*Plate LV. Figs. 2a, b.*

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 608, Plate 15, Figs. 3a, b, and Plate 16, Fig. 7.

1881. W. and Sp.; Revision Palæocr., Part II., p. 145.

Nearest to *A. verrucosus*, but of larger size, the plates heavier and decidedly more nodose. Calyx a little higher than wide, uniformly spreading from the broadly truncated base to the top of the second costals, whence the rays spread obliquely outward. The interbrachial spaces curve slightly inward, and form deeply depressed areas, which give to the calyx from a ventral aspect a strongly pentalobate outline. Tegmen short, depressed convex. Plates of the dorsal cup massive and highly elevated, the surfaces rising obliquely from the suture lines to near the centre of the plates, and thence abruptly to their summits, there forming conspicuous nodes, which upon the radials and brachials are transversely arranged. From these nodes, broad ridges proceed to adjoining plates, two — exceptionally three — from the radials to the basals, while there is but one between the other plates. These ridges and nodes give to the surface a rugose and rough appearance.

Basals large, projecting outward, and forming with their lower margins a strong rim around the top of the column, which is deeply notched between the plates. Radials as long as wide, or longer; their sloping upper faces much shorter than the lateral ones. First costals less than half the size of the radials, nearly as long as wide; the second as wide as the first, but only half as long. Distichals small, giving off an arm to one side, and two palmars to the other; the latter supporting on their axillary two arms, which are free from the second plate. Distichals and palmars quite short, angular on the back, and separated from adjoining brachials of the same ray by deep grooves, formed by the incurving sides of the plates. Arms six to the ray, stout, long, and apparently simple throughout. Regular interbrachials: 1, 2, 3, followed by a number of smaller plates, which gradually pass into interambulacrals, and decrease in size upwards. The anal plate, which is smaller than the radials, is followed by 2, 3, and 5 pieces. There are no interdistichals between the main divisions of the rays. Orals and all ambu-

lateral plates large and spinous, the interambulacral plates small and flat. Anal tube central and apparently large; its length unknown.

Horizon and Locality.—Keokuk group; Keokuk, Iowa, and Nauvoo, Hamilton, and Warsaw, Ills.

Type in the (Worthen) Illinois State collection, Springfield.

Actinocrinus Lowei HALL.

Plate LIV. Fig. 2.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 611, Plate 15, Figs. 5a, b.

1881. W. and SP.; Revision Palæocr., Part II., p. 144.

Syn. *Actinocrinus brontes* HALL; 1860, Suppl. Geol. Rep. Iowa, p. 47.

A large species, generally found in a flattened or crushed condition, which makes it difficult to ascertain the actual form of the calyx, though it seems to be near that of *A. permodosus*; but the brachial extensions are larger, their plates proportionally longer, the interbrachial depressions deeper, and the tegmen higher. Besides, it has eight arms to the ray in place of six. The ornamentation is nearly the same as in that species, but somewhat more symmetrical; the plates are thinner, and the central nodes less prominent.

Basals large, forming a slightly spreading cup, a little thickened at the sides, rounded on the lower margins, and the place for the attachment of the column slightly excavated. Radials large, as long as wide, or longer. First costals generally hexagonal, less than half the size of the radials. The second costals smaller than the first, directed obliquely outward, and incurving at the sides to form the bases of the brachial extensions, which from the distichals extend horizontally to the bases of the free arms, widening outwards. The brachials of the higher orders are comparatively large, slightly nodose on the back, the sides incurving and deeply grooved, especially between the main divisions, where the grooves are also wider, and have at the bottom a longitudinal row of three or four interdistichals. Distichals wider than the costals; all axillary, giving off at their outer sides an arm, which is free from the third plate, at the inner two palmars, which from the axillary support the second arm and two post-palmars, of which the upper one bifurcates again, and sustains two arms. The arms themselves have not been observed. Regular interbrachials: 1, 2, 3, 8; the outer ones of the

fourth row extending far out on the brachial extensions. There are numerous other interrarial plates above, but these take part in the tegmen. The anal piece supports two plates in the first row, two in the second, and numerous other plates above. Ventral disk depressed convex, somewhat bulging above the rays; the orals and ambulacral plates sharply nodose; the interambulacrals almost flat. The orals are not in contact, being separated by small, flat pieces. Ambulacral plates arranged in alternate rows, which bifurcate from a large axillary, and form secondary and tertiary rows toward the arms. Anal tube nearly central.

Horizon and Locality.—Keokuk group; Keokuk, Iowa, and other places in Missouri and Illinois.

Actinocrinus jugosus HALL.

Plate LIV. Fig. 1.

1860. HALL; Suppl. Geol. Rep. Iowa, p. 49.

1881. W. and Sr.; Revision Palæocr., Part II., p. 144.

A large species, also always found in a crushed condition, so that its form cannot be accurately ascertained. It seems to be nearest to *A. Lowei*, which it resembles in the mode of ornamentation, but from appearances the calyx is more elongate, the plates thinner and more evenly proportioned, the brachial extensions less prominent, the interbrachial spaces considerably narrower, and the higher brachials of the calyx much shorter and smaller generally, indicating also that the arms were much thinner. Plates convex, traversed by ridges which meet in nodes at the centres; the nodes of the radials, costals, distichals and anal plate transverse, those of the interbrachials round. From those of the radials four ridges pass down to the basals, three others upward to the first costals, and sometimes the same number runs to the second costals, but there is never more than one ridge between the other plates.

Basals forming a wide cup, with a slightly projecting, smooth collar at the lower end, and deeply grooved at the interbasal sutures. Radials and both costals longer than wide; the latter about one half the size of the radials. Distichals a little smaller than the costals, nearly as long as wide, and all axillary, giving off an arm to one side, and two palmars to the other. The two lower fixed arm plates are nodose, as wide as long, and as large as the palmars of the opposite side, of which the second is axillary, and gives

off another arm and two post-palmars with two arms. The second arm is free from the second plate, the two upper ones from above the first. Higher brachials separated by deep longitudinal grooves, formed by the lateral incurving of the respective plates; post-palmars very short, resembling free arm joints. Structure of the arms unknown. Interbrachial spaces narrow, the plates of the regular sides arranged: 1, 2, 3, 3, 3, 3; the anal plate, which is smaller than the radials, is followed by 2, 3, 4, and several higher rows, of which the exact arrangement cannot be ascertained. Interdistichals three or four; rather large. The form of the tegmen is given by Hall as "conical, rising gradually from the arm bases to the base of the central proboscis." This appears so in the flattened specimen, but we doubt if its natural form was conical. Plates around the summit moderately large and tuberculiform, those covering the brachial extensions somewhat smaller, the interambulacral pieces still smaller and but slightly convex.

Horizon and Locality. — Same as last.

Type in the (Worthen) Illinois State collection.

***Actinocrinus multiramosus* W. and Sp. (nov. spec.).**

Plate LIII. Fig. 1, and Plate LV. Fig. 3.

(?) Syn. *Actinocrinus grandis* S. A. MILLER, 1890 (not Lyon 1859); Desc. New Genera and Spec. of Echinod., p. 25, Plate 5, Fig. 1, and Plate 6, Fig. 1.

A large species of the type of *A. Lowei* Hall, with which it closely agrees in the mode of ornamentation; differing, however, in the more slender form of the calyx, the number of palmars and distichals, in being less distinctly lobed, and in having within the calyx three bifurcations in place of four. Calyx obconical to the top of the first costals, broadly truncated at the base; the distichals and higher orders of brachials given off in clusters, bending outward and obliquely upward to the bases of the free arms; the interbrachial spaces deeply depressed, and the interspaces between the main divisions of the ray deeply grooved. Ventral disk depressed-convex, occupying from one fourth to one third the height of the calyx, and surmounted by a strong tube which rises abruptly from the summit. Plates of the dorsal cup heavy and convex, their surfaces covered with sets of well defined ridges which traverse the suture lines, and also by large nodes. The nodes are placed near the middle of the plates, and those upon the

radials, first costals and anal plate are transversely elongate, and occupy nearly one fourth the surface of the plates; while those upon the interbrachials, which have a circular outline, are proportionally smaller. There are generally three ridges between the radials, basals and costals, but these are not continuous, extending only to the margins of the nodes; two proceed to the first interbrachials, while the other plates up to the brachial extensions are connected by single rows. Suture lines distinct.

Basals large, forming a broad and deep cup, which at its lower margin is distinctly notched; the lower edges of the plates expanding, and forming a smooth, thickened, trilobate rim, which stands out conspicuously from the column. Radials as wide as long — in very large specimens proportionally longer — more than twice as large as both costals together; the lateral faces longer than the sloping upper ones. First costals nearly as wide as long, and hexangular; the second very short, sometimes less than half the length of the first, and obliquely angular above. Distichals small, all axillary, giving off from one side an arm, which is free and biserial from the second plate, and generally simple throughout; from the other side three palmars, which support two arms, which both bifurcate once or twice in their free state at some distance from the calyx. Arms long, moderately heavy, rounded on the back, and nearly as thick at the distal end as at the proximal. Arm joints short and slightly convex. Pinnules rather thin, and only their three or four proximal joints are provided with small hooks. Interbrachials: 1, 2, 3, followed by a number of others in the equatorial region; the first as large as the first costals, those of the second and third rows smaller. Anal plate somewhat shorter than the radials; supporting two plates in the first, three in the second, and four to five in the third row. Tegmen composed of slightly convex, moderately large pieces. Orals in contact, the posterior one small and placed transversely; the others larger than any of the surrounding plates, but otherwise not distinct; they are elongate, and narrowest at the lower end, leaving notches, which enclose the first radial dome plate. The latter is followed by two plates of a second order, and these by alternate rows of minute covering pieces. Anal tube extremely long, extending far out above the tips of the arms, and heavy throughout; the plates strongly tuberculous and sharply pointed at the top, some of them larger and subspinous. Column large at the upper end, but tapering distinctly downward. The nodal joints near the calyx considerably longer and wider than the intervening ones, and angular at the edges, but gradually with their decrease

in width they grow shorter and cylindrical, while the others relatively increase in size.

Horizon and Locality.—Keokuk group; Indian creek, Montgomery Co., and Canton, Washington Co., Ind.

Types in the collection of Wachsmuth and Springer.

Remarks.—Of this large and beautiful species we obtained at Indian creek and Canton over forty specimens, most of them in excellent preservation, with the arms attached; and it is very remarkable that nearly one half of them have either a *Platyceras* attached to the tegmen, or a specimen of *Onychaster* between the arms and coiled around the anal tube. This, so far as we know, is the first instance in which a *Platyceras* has been found in contact with a Crinoid with a long anal tube; in all cases heretofore noticed the Crinoid had an anal opening directly through the tegmen, and the Gasteropod was fastened invariably with the anterior portion of the shell over the opening.* This led to the supposition, for which there seemed to be good reasons, that the Mollusk obtained its nourishment, in part at least, from the excrements of the Crinoid. This, however, was impossible in the case before us, where the anal tube, with the anus at the distal end, extends out far beyond the tips of the arms, and, so far as observed, bends abruptly to one side, so that neither the opening nor the refuse matter could have been in contact with the Mollusk.

In more frequent association with this *Actinocrinus* is the *Onychaster*, and it is worthy of note that this species of Ophiuran is rarely found by itself. Nor has it been observed at Indian creek on any of the other Crinoids, while at Canton it appears also on most of the specimens of *Scytalocrinus robustus* (Hall), a species with a large ventral tube, and the anus located far down at the anterior side; but with this exception we have not seen it on any other species. The fact that this Ophiurid is only found associated with certain species, and there always under similar conditions, and the frequency of this occurrence, would seem to indicate that the position between the arms of these Crinoids was its favorite resting place, in which it either found protection, or some special facility for obtaining nourishment. Nobody, however, who is acquainted with the anatomy of the Crinoids, and their mode of living, will entertain for a moment the notion that the Crinoid preyed either on the Ophiurid, or on the Gasteropod, as suggested by the earlier writers.

* See Synopsis of Amer. Carbon. Calyptridæ. By Charles R. Keyes. Proceed. Acad. Nat. Sci. Phila., 1890, p. 154.

It is quite probable that Miller's *Steganoocrinus Benedicti** belongs to this species. Its arms are given off in exactly the same manner, and it has the same style of ornamentation, only the calyx appears to be a little shorter than is usual in that form. We doubt if it is a *Steganoocrinus*, for the brachials of each ray, according to the figures, are in sutural contact laterally to the base of the free arms, instead of being given off from the sides of tubular appendages extending to almost the tips of the arms. It is also possible that Miller's *Actinoocrinus grandis* is identical with our species. His description is insufficient for accurate comparison, and his figures show the rays only to the first palmars. Besides the name was preoccupied by Lyon in 1859.†

***Actinoocrinus magnificus* W. and Sp. (nov. spec.).**

Plate LIII. Fig. 2.

Syn. *Actinoocrinus lobatus* WORTHEN (not Hall), 1890, Geol. Rep. Illinois, Vol. VIII., Plate 12, Figs. 8, 8a.

As large as the preceding species. Calyx apparently higher than wide, broadly truncate at the base, slightly constricted at the top of the second costals, and more deeply at the interbrachial spaces. The brachial lobes directed obliquely upward, not very prominent, and beginning from the upper end of the distichals, so that there are actually two lobes to each ray, separated by a deep sulcus, with a few interdistichals at the bottom. Plates of the dorsal cup proportionally thin and slightly convex, their surfaces marked by ridges, which are not mere surface elevations, but folds in the substance of the plates, and which gradually disappear as they pass inward. The surface of the ridges is covered by rows of obscure nodes, which produce a beautiful ornamentation; the middle of the plates is smooth or slightly tumid, except upon the radials, which have low, transverse elevations, from which three or four parallel ridges or folds pass out to the basals, while there is generally but one between the other plates.

Basals very large, forming a deep and broad cup, almost as high as wide at the bottom; the lower end not thickened nor projecting over the top of the column. Radials large, as long as wide, or a little longer; the costals one half smaller, hexangular and heptangular, the second one nearly as large as the first, and both as long as wide. Distichals all axillary, slightly

* Adv. Sheets 18th Rep. Geol. Surv. of Indiana, p. 27, Plate 4.

† Amer. Journ. Sci., Vol. XXVIII., p. 240.

convex longitudinally, one fourth smaller than the costals, and as wide as long. They support at their outer sides an arm, which from the second or third plate is free and biserial; and from the inner side three palmars, which give off two arms. There are six arms to each ray from the calyx, but these generally branch once again in their free state, rarely twice. Arms not quite as long and stout as in *A. multiramosus*, and more rapidly tapering; the pinnules stronger. The latter are composed of eight or nine very long joints, of which only the two proximal ones have hook-like processes. Regular interbrachials: 1, 2, 3, 4, 3 — sometimes three in the second row — the first larger than the costals, the succeeding ones decreasing in size upwards. Anal plate a little smaller than the radials, and followed by 2, 3, 5, and numerous other irregular plates. The form of the ventral disk cannot be ascertained, both type specimens being flattened, but it was probably depressed conical. The plates are rather large, strongly convex, rounded at the top, and nearly uniform in size. Nothing is known of the anal tube. Column very large near the calyx.

Horizon and Locality. — Keokuk group; Indian creek, Montgomery Co., Ind.

Types in the collection of Wachsmuth and Springer.

Remarks. — This species differs from the preceding one, and all others of the Keokuk group, in the thinness of its plates, and in having the ridges upon the surface produced by folds in the plates. The second costals are much larger, and while in the other species the brachial extensions begin above or below the second costals, they commence in this at the top of the distichals.

***Actinocrinus Griffithi* W. and Sp. (nov. spec.).**

Plate LII. Fig. 7.

Of medium size. Calyx higher than wide, the brachial extensions narrow; interspaces wide. Dorsal cup three times as high as the ventral disk, decidedly swelling across the middle of the radials and anal plate, where the section is distinctly angular, and wider than at the top of the first costals. Plates rather delicate, covered with ridges, which meet at the middle of the plates within a small node. There are four such ridges between the radials and basals, of which the two middle ones are the most conspicuous; one or two form a continuous ring around the radials and anal plate, while there is

generally but one between the other plates; none, however, above the second costals and second interbrachials. The ridges passing up the costals are most prominent, and the plates themselves longitudinally angular, their sides being almost even with the flattened interbrachial areas, which gives to this part of the calyx a peculiarly angular aspect.

Basals large, forming a deep cup expanding at both ends, the plates having a projecting rim or transverse ridges around their lower margins, which, being truncated toward the sutures, give to the lower face of the cup a trilobate outline. Radials large in proportion to the plates above. First costals less than half the size of the radials; the second one third shorter than the first, and directed obliquely outward. Distichals all axillary, quite small, angular on the exterior, their lateral ends bending inward. They support an arm at one side, and three palmars at the other, above which there are four more bifurcations, all taking place from the third plate respectively, giving off an arm to one side, which alternates with the arm of the preceding order, except the upper series, which supports two arms. The main arms, as well as their lateral branches, are quite delicate, the former uniserial to the fifth bifurcation, the latter biserial from their origin. Regular interbrachials: 1, 2, 4, followed by a few smaller plates, which are on a level with the arm bases, and rest against the orals. Anal plate considerably smaller than the radials, and supporting two plates in the first row, three in the second, and five or six in the third. Interdistichals unrepresented. Tegmen depressed-convex, with a strong anal tube rising abruptly from the summit; the plates tuberculous. Orals larger than the interambulacrals, and separated from each other by the ambulacral plates, which are large, and pass out between them in two well defined alternate series, diminishing toward the arms, and branching outward. Column of moderate size; the nodal joints somewhat thickest, and rounded upon the edges.

Horizon and Locality. — Upper part of Upper Burlington limestone; Burlington, Iowa, and Pleasant Grove, Iowa.

Types in the collection of Wachsmuth and Springer.

Remarks. — This species in its arm structure approaches the genus *Steganocrinus*, and is also interesting for its regularly arranged, large covering pieces, which pass out between the ambulacra. It is named in honor of Dr. Horace G. Griffith, of Burlington, who, with a liberality for which we have been often indebted to him, presented us one of the type specimens.

(P) *Actinocrinus chouteauensis* S. A. MILLER.*Plate XLVI. Figs. 11a, b.*

1892. (?) *Actinocrinus chouteauensis* — S. A. MILLER; Adv. Sheets 18th Rep. Geol. Surv. Indiana, p. 18, Plate 3, Figs. 9 and 10.

Of medium size. Calyx as wide as high, the dorsal cup three times as high as the disk, pentangular at the arm bases; the sides very slightly convex to the top of the costals, then rapidly spreading to the arms. Plates without ornamentation, convex and a little tumid; the suture lines depressed.

Basal cup moderately large, gradually spreading; the interbasal sutures well defined; axial canal large. Radials as long as wide (one of them in the type a little wider than long); the lower end of the two heptagonal ones distinctly angular. Costals considerably narrower than the radials, nearly as wide as long; the first hexangular; the second generally hexangular, and partly smaller than the first. Distichals one, small, twice as wide as long. Palmars one preserved in the specimen, very short. Arms apparently four, the arm openings directed obliquely upwards and arranged in pairs. Regular interradials 4 to 5; decreasing gradually in size upwards. Anal plate as long as, but narrower than, the radials, supporting 2, 4, and 2 plates. Ventral disk convex, the plates large and nodose. Orals large, asymmetrically arranged, the posterior one smaller than the others, and pushed in deeply between them. Ambulacral plates three, large, two of them of a second order. Interambulacrals three or four, in contact with the interbrachials. Anal tube subcentral, its length unknown.

Horizon and Locality. — Referred to the Chouteau limestone, near Sedalia, Mo.; but the color of the fossil and of the matrix leaves but little doubt that it came from the Lower Burlington.

Type in the collection of F. A. Sampson.

Remarks. — This species was described from a single specimen, which had only the calyx preserved, and the ventral disk was partly covered by matrix. On removing this, we found Miller's ideal figure of the disk (his figure 10) to be incorrect, inasmuch as the so-called large plate adjoining the posterior oral is only the base of the anal tube, as shown by our figure.

Actinocrinus tenuisculptus* McCHESNEY.Plate LV., Figs. 4a, b.*

1859. McCHESNEY; Descr. New Spec. Palæoz. Foss., p. 15.

1867. McCHESNEY; Trans. Chic. Acad. Sci., Vol. I., p. 11, Plate 5, Fig. 1.

1881. W. and Sp.; Revision Palæocr., Part II., p. 146.

Syn. *Actinocrinus chloris* HALL—1861; Boston Journ. Nat. Hist., Vol. VII., p. 275.

A moderately small species, which, in the delicacy of the plates of the calyx, the beauty of their ornamentation, the spiniferous character of the plates in the tegmen, and the long hooks upon the pinnule joints, reminds us of certain forms for which we have proposed the genus *Cactocrinus*. The calyx, however, is distinctly lobed, and the arms are arranged in clusters, which are separated by wide and deep depressions or grooves extending far up into the ventral disk, and the upper bifurcations of the ray take place from two successive palmars. Dorsal cup semiglobose, truncate at the base, with a small rim around the lower margin, the sides convex to the top of the distichals, thence slightly more spreading to the arm bases. Tegmen almost as high as the dorsal cup, subpyramidal; cross-section at the arm bases broadly quinquelobate. Plates of the dorsal cup slightly tumid, covered by radiating ridges with undulated edges, wider at the middle of the plates than at their margins. The ridges passing up and down the radials and brachials considerably the strongest, dividing the surface of the calyx into five well defined fields, which extend from the basal ring to the bases of the free arms, and enclose a well marked star at the four regular sides, while the anal side contains two somewhat smaller stars with seven rays.

Basals short, the projecting rim subcircular or obscurely trilobate, according to the greater or less depth of the sutural depression. Radials from one fifth to one third wider than long. First costals half the size of the radials, quadrangular, and nearly twice as wide as long; the second heptangular, wider and longer in proportion, obtusely angular above. Distichals rather small, all axillary, giving off an arm to the outer side, and two small palmars which support two arms to the other. Arm facets small, but the ambulacral openings comparatively large. Arms six to the ray, slightly angular below, gradually flattening above; the tips incurving. The four proximal arm joints are in single series, as long as wide, and even longer; they are cuneate, and each one has at its upper end from its longer side

a lateral projection, or sort of elongate node, which stands obliquely upward, and gives to the lower part of the arms a zigzag outline. The succeeding plates are biserial, and of these the three or four lower ones are considerably higher than those above. The upper margins of the arm pieces project slightly over the lower margins of the succeeding ones, the sides are serrated, and the lines of union between them somewhat waving. The three or four proximal pinnule joints are provided with moderately long hooks. Regular interbrachials: 1, 2, 2; the first very large, rising to the middle of the second costals, the two of the upper row quite minute. Anal plate as long as, but narrower than the radials, followed by 2, 3, and 3 pieces. Interdistichals one. The grooves between the rays extend up almost vertically to one half the height of the tegmen, and are paved by rather large, flat pieces; while the orals and ambulacral plates are spiniform. Orals pushed out far to the anterior side; they are comparatively small and in close contact; the ambulacral plates arranged in alternate rows. Anal tube nearly central, moderately large, and composed of spinous plates.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa, Sedalia, Mo., and Lake Valley, New Mexico.

***Actinocrinus gracilis* W. and Sp. (nov. spec.).**

Plate LVI. Fig. 11.

Approaching *A. tenuisculptus*, but a smaller species, and having a much larger number of arms; also the ornamentation of the plates more obscure. Dorsal cup bowl-shaped, the sides to the top of the distichals slightly convex, then bending abruptly outward; the plates a little tumid, covered by faint radiating striæ and well defined ridges, the latter following the rays, and forming deep depressions at the interdistichal spaces.

Basals small, with a slightly projecting rim. Radials one third larger than the costals, and both wider than long. Distichals 2×10 . Three bifurcations occur in the calyx, and one or two in the arms, all taking place from the second plate, and all above the first axillary from one side only, the opposite sides giving off a free arm. Arms from eight to ten to the ray, quite slender, a little wider at the upper end than at the lower; the three or four proximal plates of each arm long and cuneate, and their widest sides, toward the upper end, provided with a short lateral node, which gives to the lower

part of the arm a zigzag outline. The upper parts of the arms have serrated sides, and are composed of two series of moderately long pieces. Regular interbrachials: 1, 2, 2; the anal plate followed by 2, 3, and 3 plates. Interdistichals one, large. Ventral disk not visible in the specimens.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Types in the Museum of Comparative Zoölogy, and in the collection of Wachsmuth and Springer.

Actinocrinus tuberculosus W. and Sp. (nov. spec.).

Plate LII. Figs. 8a, b, c.

Of the type of *A. tenuisculptus*, but somewhat larger. Calyx a little higher than wide, the dorsal cup considerably shorter than the tegmen. Plates rather thin, the surface slightly convex, and ornamented by series of isolated nodes of various forms. The middle of the plates is occupied by a conical, sometimes rounded tubercle, which is surrounded by elongate nodes, directed one to each side, with their longer diameter toward the margins of the plates. From the middle of the second costals upward, sometimes even from the radials, the nodes are set close together in rows, and form high and sharp knife-like ridges with serrated edges, running to the bases of the free arms.

Basals short, wider at the lower margin than at the upper, at the latter surrounded either by a thickened collar, or by a row of conspicuous nodes, of which there are generally three to each plate. Radials one third wider than long. First costals half the size of the radials, and quadrangular; the second a little wider than the first, and heptangular. Distichals and palmars keel-shaped; the former smaller than the costals, and once and a half as wide as long; the latter still smaller, and the angularity extending over the entire width of the plates. Arms three to each main division of the ray, or thirty in all, given off in the usual way; the proximal one from the outer sides of the distichals, the two others from the second palmars; they are long, flat, wider in the upper part than at their bases; the lateral margins serrated. The four proximal arm plates are single, very high and cuneate, a thorn-like projection extending out from their longer sides. The plates, as the arms become biserial, are short, and each one is covered with a transverse row of small pustules. Pinnules long, and to one half their

length provided with short hooks. Regular interbrachials: 1, 2, 3; the first almost as large as the radials; the plates of the upper row interlocking with those from the tegmen. The anal piece is followed by 2, 3, and 4 plates. Interdistichals one. Tegmen short, the interambulacral plates and orals flat, all of nearly the same size; the ambulacral pieces the smaller, a little convex and formed into ridges. Anal tube of medium size, the plates covered with a minute central tubercle. Column moderately large, the nodal joints widest, their edges convex, and bordered by small nodes.

Horizon and Locality. — Upper Burlington limestone; Burlington and Pleasant Grove, Iowa.

Types in the collection of Wachsmuth and Springer.

Remarks. — This species differs from *A. tenuisculptus*, with which it has its closest affinities, in the mode of ornamentation of the dorsal cup, the wider interspaces between the rays at the arm regions, and in having flat instead of spiniferous plates in the tegmen. It also occurs at a different geological horizon.

***Actinocrinus daphne* HALL.**

Plate LVI. Fig. 1.

1864. HALL; 17th Rep. N. Y. State Cab. Nat. Hist., p. 52.

1875. HALL; Geol. Surv. Ohio, Palæont., Vol. II., Part II., p. 162, Plate 11, Fig. 11.

1881. W. and SE.; Revision Palæocr., Part II., p. 143.

Calyx of medium size, its exact form indeterminable owing to the crushed condition of the specimens; the base truncated only to the width of the column; the rays but slightly lobed; the arms given off in clusters as in *A. tenuisculptus*, with moderately wide interspaces between the rays. Plates rather delicate; their surface marked by radiating ridges running from the centre of the plates to their margins, where they meet those of adjoining plates. The ridges passing up the radials and brachials, and down to the basals, somewhat more prominent.

Basals rather large, forming a spreading cup with a slightly projecting, narrow rim around the lower margin, which is readily taken for the upper stem joint; interbasal sutures indistinct. Radials longer than wide; the costals wider than long; the first hexagonal, smaller than the second, and less than two thirds the size of the radials. Distichals smaller than the first costals, supporting at one side an arm, at the other two palmars with two

arms from the axillary. Arms six to the ray, rounded on the back* and slightly tapering, biserial from the third plate up. Pinnules extremely long, and to nearly their full length provided with small hooks, which slightly overlap the adjoining pinnule above. Regular interbrachials: 1, 2, 2; the anal plate followed by 2, 3, and 3 plates. Structure of the ventral disk unknown. Anal tube long, slender in the upper part, and composed of small convex pieces. Column of more than average size; the nodal joints projecting, and rounded at their outer margins.

Horizon and Locality. — Waverly group; Richfield, Ohio.

Types in the New York State Cabinet at Albany, N. Y.

Remarks. — This and the two preceding species form a little group by themselves, approaching in some of their characters *Cactocrinus*; but they must be referred to *Actinocrinus*, as the arms of the different rays are arranged in groups, which are separated by a number of interbrachial plates, and the bifurcations above the distichals take place from the second plate of each order, and not from the first as in that genus.

***Actinocrinus asperrimus* (M. and W.).**

Plate LX. Figs. 5 and 6.

1869. *Strotocrinus* (?) *asperrimus* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 160. Also Geol. Rep. Illinois, Vol. V., p. 349, Plate 8, Fig. 3.

1881. *Actinocrinus asperrimus* — W. and SP.; Revision Palæocr., Part II., p. 142.

Calyx of medium size, urn-shaped, its width at the arm bases equal to its length. Dorsal cup obconical to the top of the costals; the distichals and the succeeding fixed brachials spreading horizontally, but without forming a continuous rim, there being deep interrachial grooves, and smaller ones between the main branches of the rays. Plates almost flat to strongly convex, their ornamentation somewhat variable, Figs. 5 and 6 representing the extremes, and the type figured by Meek and Worthen an intermediate form. In all these specimens, however, there are ridges radiating from the centres of the plates to adjoining ones, three generally between the radials and basals, and one between the other plates.

Basals three times as wide as high, deeply grooved along the sutures, and distinctly lobed from a dorsal aspect; the lower edges scalloped and

* A flattening of the arms, as described by Hall, does not exist in any of our specimens.

slightly projecting outward; axial canal very small. Radials and anal plate nearly or fully as long as wide. First costals one third smaller than the radials; the second costals narrower than the first, and smaller generally. Higher brachials gradually decreasing in size upward, each one supporting an arm at one side, and the upper one two arms. Arms normally eight to the ray; small, to judge from the size of their facets. Regular interbrachials: 1, 2, 2, against 2, 3, 2 at the anal side, followed by two very small pieces between the lobes. Interaxillaries one, which, like the interbrachials, meets with the plates of the tegmen. Ventral disk less than one third the height of the calyx, depressed conical, deeply grooved toward the margin. The plates are quite small, scale-like, slightly convex, and of nearly uniform size. Orals indeterminable, but there are along the line of the ambulacra, over each ray, three plates somewhat larger than the others, which may represent radial dome plates of a first and second order. Anal tube almost central, small for the genus.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.
Type in the Illinois State Collection at Springfield.

Remarks. — This species, which represents a transition toward *Teleocrinus*, is readily distinguished by the depressed form of the disk, and the scale-like plates of which it is composed.

***Actinocrinus trijugis* (S. A. MILLER).**

Plate LIV. Figs. 4a, b.

1891. *Blaiocrinus trijugis* — S. A. MILLER; Adv. Sheets 17th Rep. Geol. Surv. Indiana, p. 69, Plate 11, Figs. 1, 2, 3.

A small species of the type of *A. tenuisculptus*. Calyx wider than high, distinctly lobed between the arm bases. Dorsal cup low cup-shaped, about twice as wide as high, the sides rapidly spreading and convex. Surface of plates covered with angular radiating ridges, which meet in a small node at the centre of the plates; there being one ridge to each side except from the antero-lateral radials and anal plate, whence two ridges pass to the basals. The ridges passing up the radials and brachials somewhat the strongest.

Basals small, forming an almost flat hexagonal disk, which is but little larger than the column, and has a small, pentangular axial canal. Radials large, nearly as long as wide. First costals quadrangular, twice as wide as long; the second a little larger and pentangular. Distichals moderately

large and axillary. Of the palmars only one plate is preserved, and so the number of arms cannot be accurately ascertained from the specimen; but to judge from the size of the arm openings, it is quite probable that it had an additional bifurcation, and the species had six arms to the ray, but not eight as suggested by Miller. Arm facets directed horizontally. Regular interbrachials: 1, 2, 2; the first very large, rising to the top of the second costals; those of the third range meeting the interambulacrals. Anal plate smaller than the radials, followed by 2, 2, and 2 plates. Ventral disk convex, composed of but few plates. The ambulacrals, which are represented by three large pieces over each ray, are spinous; while the orals are almost flat. Anal tube stout at the base, but rapidly increasing in size upwards.

Horizon and Locality. — Chouteau limestone; near Sedalia, Pettis Co., Mo.

Type in the collection of S. A. Miller.

Actinocrinus arrosus (S. A. MILLER).

Plate LV. Figs. 7, and 8a, b, c.

1892. *Blairocrinus arrosus* — S. A. MILLER; Adv. Sheets 18th Rep. Geol. Surv. Indiana, p. 41, Plate 7, Figs. 1 to 5.

Syn. *Blairocrinus bullatus* S. A. MILLER; *ibid.*, p. 41, Plate 7, Figs. 6 and 7.

Of medium size. Calyx distinctly quinquelobate, its height equal to three fourths its width in well preserved specimens. Dorsal cup saucer-shaped, its height less than half that of the ventral disk; the surface deeply sculptured; the radial plates being strongly keel-shaped, the interrarial ones provided with a sharp central node, leaving deep, pit-like depressions between the nodes and the ridges. Suture lines indistinct.

Basal cup small, projecting but little beyond the column, and only the angles of the plates bending upwards; it is notched at the sutures, and trilobate in outline. Radials a little wider than long, covered with a transverse node. Costals as wide as the radials, but only half as long; the first quadrangular; the second pentangular and generally a little larger than the first. Distichals one, small, axillary, supporting apparently a single palmar. Arm openings twenty, arranged in pairs, and directed horizontally or slightly downward. The number of arms unknown. Interrarial spaces subovate, composed at the regular sides of three plates, of which the two upper are quite small, and placed level with the arm openings. The anal plate as large as the radials, and similarly sculptured; it supports two plates in the

first, and two in the second row. Ventral disk highly elevated and bulging at the outer margins, where the plates stand erect. Orals nodose, pushed over to the anterior side, and in the larger specimens separated by accessory pieces. Radial dome plates as large as the orals, strongly nodose and sometimes subspinous. The interambulacral plates in contact with the interbrachials. Anal tube subcentral, rather large at the base.

Horizon and Locality. — Chouteau limestone; Sedalia, Mo.

Types in the collection of F. A. Sampson, Sedalia.

Remarks. — This species is closely related to *Actinocrinus* (*Blairocrinus*) *trijugis*, if not identical with it. Miller claims the latter species has eight arms to the ray, and the other but four, neither of which is clearly shown by the specimens. However, there can be no doubt that Miller's "*Blairocrinus*" *bullatus* is identical with this species. We examined a number of specimens from the collection of Mr. Sampson, some of which were labeled by Miller *B. arrosus*, others *B. bullatus*, and found that he had described the plumper specimens as *B. bullatus* and the crushed ones as *B. arrosus*. We also became convinced that the anus of this species is not so excentric as it appears in Miller's figures, which represent it when pushed out of place by oblique pressure, but that its position is almost central. This is clearly shown by Mr. Sampson's beautiful specimen, of which we give three figures on Plate LV., Figs. 8a, b, c.

STEGANOCRINUS MEEK and WORTHEN.

1866. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 195, also *ibid.* Vol. III., p. 474.
 1879. ZITTEL (subgenus of *Actinocrinus*); Handb. d. Palæont., Vol. I., p. 370.
 1881. W. and SP.; Revision Palæocr., Part II., p. 149 (Proceed. Acad. Nat. Sci. Phila., p. 323).
 1889. S. A. MILLER; N. Amer. Geol. and Palæont., p. 282.
 Syn. *Actinocrinus*; SHUMARD, 1855; HALL, 1860; MEEK and WORTHEN, 1860.

In its general structure resembling *Actinocrinus*, but the rays, instead of being produced into mere lobes, are formed into arm-like, tubular extensions or trunks, which rise to the full length of the crown, giving off armlets alternately from opposite sides. There are either one or two of these brachial trunks to the ray, according to species, depending on whether they take their origin from the costals or distichals; they were apparently rigid, and movable, if at all, only as a whole. The dorsal side of these appendages is formed by a longitudinal row of axillaries, or by a succession of syzygies, in which latter case the second plate of the various orders is arm-bearing.

They are closed ventrally by two rows of small, irregular side-pieces, which rest upon the inflected edges of the brachials, and enclose a single row of rather large, cuneate, spinous covering pieces, alternately arranged. The upper angle of the brachials is irregular in position, the side bearing the arm considerably shorter and distinctly sloping, the other one, supporting the next brachial, horizontal. The arms are given off at the sides, the proximal joint resting upon the axillary below, and against the truncated lower face of the plate above; they are much smaller than the trunks, biserial, and pinnule-bearing. In all other points the genus resembles *Actinocrinus*.

Distribution. — Known only from America, and here only from the Kinderhook group and Burlington limestone.

Type of the genus: *Steganocrinus pentagonus*.

***Steganocrinus pentagonus* (HALL).**

Plate LXI. Figs. 3a to e; and 4a, b.

1858. *Actinocrinus pentagonus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 577, Plate 10, Figs. 6a, b.
 1866. *Steganocrinus pentagonus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 196.
 1868. *Steganocrinus pentagonus* — MEEK and WORTHEN; *ibid.*, Vol. III., p. 474, Plate 16, Fig. 8.
 1881. *Steganocrinus pentagonus* — W. and SP.; Revision Palæocœ, Part II., p. 151.

Calyx of medium size, wider than high, distinctly pentangular in its dorsal and ventral aspect. Dorsal cup nearly twice as high as the tegmen, its sides slightly convex to the top of the first costals, the second costals and distichals bent abruptly outward, the latter to a horizontal position, forming five calycine extensions, which bifurcate from the second costals into two free trunks, which bear arms alternately from each side. Plates of the cup thin and but very little convex; their surfaces marked by radiating ridges, which meet in the centre of the plates, where they form small nodes. The ridges are in single series, except between the radials and basals, where there are two.

Basals rather small, forming a short, rapidly spreading cup without projecting marginal rim; the suture lines slightly grooved. Radials and first costals proportionally large, about as long as wide, the latter a little the smaller, and their sides inflected at the upper end to receive the second costals, which are small and distinctly rounded on the back. Distichals 2×2 , connected laterally, about half the size of the upper costals, and twice as wide as long, each giving off an arm laterally, one from the one side, the

other from the opposite. The second distichals are cuneate, so that the sloping upper faces of both together serve as an axillary, from which are given off the free arm trunks. Each succeeding order of brachials in these branches consists of a single plate, which in form and size resembles the arm-bearing distichals, and each one is irregularly axillary, supporting upon its shorter sloping side an arm, upon the longer upper side a brachial of a higher order. The exact number of successive bifurcations cannot be ascertained, but there were not less than forty from each appendage in full grown specimens. The upper and lower faces of the brachials are parallel, their dorsal or outer surfaces somewhat convex or transversely angular. The trunks are nearly three times as thick as the arms, and taper but slightly. Their inner cavity, which is oval in outline, is roofed over ventrally by two series of side pieces, which enclose a row of large, distinctly cuneate covering plates, alternately arranged, and extended into long, upright spines. The apposed faces of the lower brachials, from the costals up, have a perforate transverse ridge, and the facets of the proximal arm joints also are perforated, but have in place of a ridge a concave surface. From the rigid ventral structure of these appendages, it seems impossible that there could have been any mobility between the brachials, but there was evidently some sort of articulation at the base of the arms. Arms very short and of equal length. They are given off at almost right angles, are biserial, somewhat flattened, and every arm joint on either side is produced laterally into a prominent spine. At the side of each arm, close to the base, there is a small respiratory pore. First interbrachials larger than the first costals, followed by four plates, which are placed on a level with the arm trunks, the two outer ones, which are somewhat smaller, being in part interambulacral; they bend outward, and help to form the trunks. The anal plate is smaller than the radials, and supports two plates in the first row and five in the second, the latter arranged like the corresponding plates of the regular sides. Tegmen depressed, surmounted by a moderately large anal tube, rising abruptly from the summit; the plates are large, almost flat, and either perfectly smooth, or crowned by a small central tubercle. Orals in lateral contact; the posterior one unusually small and lunate, its place being largely taken up by the tube. The ambulacral plates elevated, alternately arranged in two rows; the axillary plate spinous. The plates of the anal tube strongly nodose.

Horizon and Locality.—Lower Burlington limestone; Burlington, Iowa, Sedalia, Mo., and Lake Valley, New Mexico.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — In the specimens from New Mexico, the entire surface of the calyx is covered with numerous irregular pustules, which are not represented in specimens from the eastern localities.

Stegancrinus araneolus MEEK and WORTHEN.

Plate LXI. Figs. 2a, b.

1860. *Actinocrinus araneolus* — M. and W.; Proceed. Acad. Nat. Sci. Phila., p. 337.

1866. *Stegancrinus araneolus* — M. and W.; Geol. Rep. Illinois, Vol. II., p. 193, Plate 15, Figs. 1a, b.

1881. *Stegancrinus araneolus* — W. and Sp.; Revision Palæocr., Part II., p. 151.

This form in its general structure agrees so closely with the preceding one, that the question arises whether it is not a mere variety of that species, or perhaps its young stage. But the differences, such as they are, are so constant among a large number of specimens, that it has been deemed safer to treat it as a full species. It is not necessary, however, to give a repetition of the general structure, but it will suffice to point out the special characters in which the two forms differ.

Calyx from one half to one fourth the average size of *S. pentagonus*, and proportionally more depressed, its width to the top of the first costals equal to once and a half its height. The plates of the dorsal cup more tumid, and the ridges more prominent; those of the tegmen more evenly nodose. The basals are shorter, and almost invisible from a side view. It has but one row of distichals instead of two, and only the plate at one side of the ray is arm-bearing. There are, as in the other species, two brachial trunks from each ray, which stand out horizontally from the calyx, both arm-bearing, and each one giving off from twelve to fifteen armlets. The palmars of both ray divisions support an arm at the inner side of the ray, the post-palmars at the outer, and so on from alternate sides. As a rule, each successive order consists of a single plate, but there are occasionally syzygies, at which the arms are given off from the second plate, a fact which has never been observed in the other species. The arms are short, and their joints are not alternately spinous, but have serrated edges. In all other points this species agrees with the preceding.

Horizon and Locality. — Same as last.

Type in the (Worthen) Illinois State collection at Springfield.

Steganocrinus concinnus (SHUMARD).*Plate LXI. Figs. 5a, b.*

1855. *Actinocrinus concinnus*—SHUM.; Geol. Surv. Missouri by Swallow, Part II., p. 189, Plate 4, Fig. 5.
 1866. *Actinocrinus concinnus*—MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 200, Plate 15, Figs. 9a, b.
 1881. *Steganocrinus concinnus*—W. and SP.; Revision Palæocr., Part II., p. 151.
 Syn. *Actinocrinus validus*—MEEK and WORTHEN; 1860, Proceed. Acad. Nat. Sci. Phila., p. 384.

Another species closely related to *S. pentagonus*, but larger, the plates more robust and of different proportions, the first costals comparatively smaller, the second much shorter and smaller generally, the basal cup deeper. Calyx nearly as high as wide, convex at the sides, distinctly lobed at the top of the first costals, the interrarial spaces between the brachial trunks extremely wide and depressed, the marginal part of the ventral disk constricted, the middle to the base of the anal tube almost flat. Dorsal cup decidedly convex, thick and heavy in the middle portions, thinning out toward the margins. The edges of the plates marked by low, rounded ridges, which either in single series or in groups of two or four traverse the suture lines, and proceed to the margins of adjoining plates, leaving the greater part of the plates perfectly smooth. The ridges are not only surface elevations, but originate in part from a folding of the plates themselves; they extend only to the centre of the first costals and second interbrachials, not to the upper portions of these plates, nor to any of the plates above.

Basals large, forming a spreading cup, with well defined suture lines, and sharply angular lower margins. Radials about as wide as high, considerably larger than both costals together. First costals generally about half the size of the radials, hexangular, the sides inflected at the upper end, the upper lateral faces longer than the lower, the upper faces narrow, semicircular, concave, and perforated. Second costals hexangular, very short, curved like arm plates, their upper angles obtuse. The higher brachials are not preserved in the specimens, but the general structure indicates that they formed two trunks from each ray with an oval cavity. First interbrachial as large as, or larger than, the first costals, followed by four plates, which are about level with the appendages; the two outer ones a little the smaller, bending outward, and in part interambulacral. Anal plate smaller than the radials, supporting two plates in the first, and five in the second range. Ventral disk very slightly elevated, the plates convex, the anal tube somewhat excen-

tric. The ambulacra roofed by two rows of large covering pieces, which are more regularly arranged in young specimens (Fig. 5*b*), in which the interambulacra are less numerous. The same is the case with the orals, which in the smaller specimens are in contact, but separated by perisomic plates in larger ones.

Horizon and Locality. — Only found in the upper part of the Upper Burlington limestone; Burlington and Pleasant Grove, Iowa, and Marion Co., Mo.

Type in the (Worthen) Illinois State collection at Springfield.

Remarks. — Specimens of this and the two preceding species are most commonly found with the axillary costals and all succeeding plates broken off, which might give the impression, to a person judging by such a specimen alone, that the calyx contained only one plate above the radials.

***Steganocrinus sculptus* (HALL).**

Plate LXI. Figs. 1a to f.

1853. *Actinocrinus sculptus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 582, Plate 10, Figs. 11*a*, *b*.
1866. *Steganocrinus sculptus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 197.
1881. *Steganocrinus sculptus* — W. and SF.; Revision Palæocr., Part II., p. 151.

Calyx rather large, biturbinate, somewhat higher than wide, the dorsal cup but little higher than the ventral disk, its sides convex to the top of the costals. The higher brachials bend obliquely outward, and their sides upward, so as to form with the ambulacral plates above five long tubular appendages, one to each ray, from which the arms are given off alternately from every second plate at opposite sides. Plates thin, highly ornamented with series of well defined angular ridges passing from plate to plate. From the middle of the radials and anal plate, three to five of these ridges proceed to the basals, three to the first costals, and 1, 2, or 3 to adjacent radials and first interbrachials; while there is generally but one ridge between the other plates, of which that between the costals is decidedly the heavier and rounded on the back.

Basals moderately large, forming a spreading cup, with slightly angular lower margin; the interbasal sutures distinct but not grooved; axial canal large, and apparently circular. Radials about as wide as long. First costals nearly one half smaller than the radials, slightly wider than long, and hexangular. The second costals much smaller than the first, and irregularly axillary; one of their upper faces short and distinctly sloping, the other

almost horizontal; the former supporting an arm, which is free from the second plate, the latter two distichals. The succeeding arms are given off in exactly the same manner as the first; every second brachial is axillary and supports on its shorter sloping side an arm, and on the opposite side two brachials of a higher order, until finally near the tips of the arms the last axillary gives origin to two arms. In large specimens there are not less than fifty orders of brachials to each ray — a very young specimen before us has but fifteen, and a somewhat larger one twenty-two — and these form straight, arm-like, apparently inflexible trunks, which at the proximal ends are four or five times as heavy as the armlets. The plates of which they are composed are short, three or four times as wide as long, with crenulated apposed faces, the armlets resting against both plates. The inner cavity of the appendages is quite large, suboval in outline, the longer diameter directed dorsally and ventrally, and the tubes themselves taper but little upward. Their ventral side is roofed by a simple row of large, spinous covering pieces, somewhat wedge-shaped and alternately arranged, together with small, triangular side-pieces, which are united with the brachials and covering plates by close suture. First interbrachial as large as the first costals, the two plates of the second range but very little smaller, those above much smaller and irregularly arranged, varying in the third row from three to five, and in the fourth from five to seven, the latter meeting the tegmental plates. Tegmen high, contracted in the lower part, then rising almost vertically, and rounded near the summit; it is composed throughout of small, spinous pieces, sharply pointed at the upper end, and so irregular in their arrangement that neither the orals nor any of the other disk plates can be identified. At one side of each trunk, and always opposite the first arm, within the tegmen, there is a large respiratory pore; and smaller ones occur along the appendages aside of every arm. Anal tube rather small and nearly central. Column of moderate size, the joints so short that at 30 mm. from the calyx it contains sixty joints with fifteen internodes. The nodal joints very little wider than the intervening ones.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa, and Lake Valley, New Mexico.

Type in the collection of Prof. Worthen.

Remarks. — This species differs from all others in having but five brachial trunks in place of ten, and in having the lower brachials much more deeply incorporated into the dorsal cup.

***Steganocrinus globosus* W. and Sr. (nov. spec.).**

Plate LXI. Fig. 6.

Calyx almost perfectly globose; the distichals a little projecting so as to give to the section a very slightly pentangular outline; the interspaces between the rays wide, but not depressed as usual in this genus; the plates nearly flat, and apparently without ornamentation.

Basals small, disk-like, and following the general curvature of the calyx. Radials and costals slightly decreasing in size upward, all one third wider than high; the first costals hexangular; the second generally heptangular. Of the distichals only one row is preserved, but its plates not being axillary they were followed by another row horizontally disposed, as their facets are directed outward. There are two openings above, which apparently represent the inner cavity of the two ambulacral appendages; they are large and close together. Regular interbranchials: 1, 2, 2, 3, followed by the plates of the tegmen. Anal side much wider, the anal plate, which is as large as the radials, supporting 2, 3, 6, and 6 or 7 plates above. Ventral disk hemispherical, as high as the dorsal cup; composed of numerous almost flat pieces of nearly uniform size; the ambulacral pieces arranged in two rows, which branch on the disk. Anal tube somewhat excentric and rather small.

Horizon and Locality. — Oolitic bed of the Kinderhook group; Burlington, Iowa.

Type in the collection of Wachsmuth and Springer.

Remarks. — The unique specimen from which this species is described is not sufficiently perfect to indicate positively its generic relations. It agrees, however, in all essential characters with *Steganocrinus*, and we regard it as an early, not fully developed form of that genus.

AMPHORACRINUS AUSTIN.

1848. AUSTIN; Quart. Journ. Geol. Soc., London, Vol. IV., p. 292.
 1855. ROEMER; Lethæa Geognostica (Ausg. 3), p. 249 (in part *Agaricocrinus*).
 1861. HALL; Boston Journ. Nat. Hist., p. 280 (in part *Agaricocrinus*).
 1866. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 209 (in part *Dorycrinus*).
 1879. ZITTEL; Handb. d. Palæont., Vol. I., p. 370 (subgenus of *Actinocrinus*).
 1881. W. and SP.; Revision Palæocr., Part II., p. 151 (Proceed. Acad. Nat. Sci. Phila., p. 325).
 1889. S. A. MILLER; N. Amer. Geol. and Palæont., p. 223.
 Syn. *Amphora* CUMBERLAND; 1826, Reliqu. Conserv., p. 36.
 Syn. *Actinocrinus* PHILLIPS, 1836; Portlock, 1843; McCoy, 1844; and Hall, 1860 (Suppl. Geol. Rep. Iowa).

The rays of the calyx, like those of *Actinocrinus*, extended outward, and forming five lobes, which are distinctly separated by the plates of the inter-radial areas. In *Amphorocrinus*, however, the dorsal cup is shorter, either flat or saucer-shaped; the proximal part of the brachial lobes projects downward, hiding the whole or a part of the cup from a side view. The ventral disk also is proportionally much higher, and provided with an excentric, very short anal tube, while the tube of *Actinocrinus* is nearly central and very long. In the known species there are never any radiating ridges upon the plates, the entire surface of the calyx presenting a rather uniform, granular appearance, peculiar to this genus, which is difficult to describe. Basals three, short, disk-like. The rays free from the top of the second costals or first distichals, whence they extend outward and downward. Arms heavy and biserial, either branching or simple; in the latter case provided with lateral spines, given off at intervals from opposite sides. Anal plate generally smaller than the radials, and followed either by two or three plates, of which the middle one, when present, is cuneate, and wedged in between the other two, often barely touching the anal. The second row of interbrachials stands on a level with the brachial lobes, and the plates are in part interambulacral. Orals large, and always more or less spinous. Ambulacra apparently covered by perisomic plates to the base of the free rays. Column round, of moderate size, and with a small, pentangular or five-rayed canal.

Distribution.—Restricted in America, so far as known, to the Waverly group and Lower Burlington limestone; in Europe it occurs in the Carboniferous limestones of Great Britain. Only three species are recognized by us in America, and a like number is recorded from Europe.

Remarks.—Cumberland, in 1826, proposed the name *Amphora* for two species, which he distinguished as No. 1 and No. 2. The former, and the

only one to which his description applies, is an *Actinocrinus*. The other was made by Austin in 1848 the type of *Amphoracrinus*, and is now known as *Amphoracrinus Gilbertsoni* (Miller) = *Actinocrinus amphora* Portlock, and *Melocrinus amphora* Goldfuss.

Roemer and Hall confounded *Amphoracrinus* with *Agaricocrinus*, and Meek and Worthen at first with *Dorycrinus*, but afterwards accepted the genus in its present form. It differs from both genera essentially in the arm structure, as well as in the form and position of the anus; and they have also uniformly a second anal plate.

Amphoracrinus appears to be a somewhat aberrant form, and has quite frequently three plates above the anal piece. This, however, is found only among the American species, and only in *A. divergens* and *A. viminalis*; *Amphoracrinus spinobrachiatus* and the three English species always having the usual two plates. This might seem to indicate that the two former are generically distinct, and should be removed to the Batocrinidæ, if it were not for the fact that they also have occasionally but two plates above the anal, and that in their arm structure, as well as in other respects, they agree most closely — even more than *A. spinobrachiatus* — with the typical form from England, of which we have a most excellent specimen with arms, from Waterford, Ireland. To understand the case correctly, it is important to note that the middle plate over the anal, when it does occur, is comparatively small and cuneate, often barely touching the anal plate; and we think it not improbable that it really represents a plate of the second row, and is not a true homologue of the middle plate in the Batocrinidæ. On the other hand, we must remember that *Amphoracrinus* is one of the earliest representatives of the Actinocrinidæ; and it may be possible that it is a transition form, in which the Actinocrinoid structure has not been as yet persistently established. At any rate, we see no good reason for separating the two forms, even subgenerically.

Worthen, in the Geol. Rep. of Illinois (Vol. VIII., p. 96, Plate 14, Fig. 8), described a specimen under the name of *Amphoracrinus jerseyensis*, which is interesting as having but four arm-bearing rays, the free parts of the anterior ray evidently having been destroyed during the life of the animal, and the break closed by abnormal growth. The specimen is too imperfect for a correct diagnosis, and we think it highly probable that it is an *Agaricocrinus*.

Amphoracrinus divergens (HALL).*Plate LXII. Figs. 5, 6a, b, 7a, b, 8a, b, c, 9, 10.*

1860. *Actinocrinus divergens* — HALL; Suppl. Geol. Rep. Iowa, p. 36.
 1881. *Amphoracrinus divergens* — W. and SP.; Revision Palæocr., Part II., p. 155.
 1893. *Amphoracrinus divergens* — WHITFIELD; Mem. Amer. Mus. Nat. Hist. N. York, Vol. I., p. 21, Plate 2, Figs. 12, 13.
 Syn. *Actinocrinus planobasilis* HALL; Suppl. Geol. Rep. Iowa, p. 19, figured in State Mus. Nat. Hist., Bull. I., Plate 4, Figs. 10 and 11 = *Amphoracrinus planobasilis* M. and W. (Geol. Rep. Illinois, Vol. V., p. 388).
 Syn. *Actinocrinus quadrispinus* WHITE, 1862, Proceed. Boston Soc. Nat. Hist., Vol. IX., p. 15 = *Amphoracrinus quadrispinus* W. and M.; 1873, Geol. Rep. Illinois, Vol. V., p. 388.
 Syn. *Amphoracrinus divergens*, var. *multiramosus* MEEK and WORTHEM, Geol. Rep. Illinois, Vol. V., p. 388.

Of rather large size. Crown in its natural condition, with all the arms preserved, as wide as, or wider than, high; the dorsal cup not visible from a side view. Calyx subpyramidal, distinctly lobed above the first costals, the interradial spaces deeply depressed between the free rays. Dorsal cup about one third the height of the ventral disk, saucer-shaped, truncated at the base. The rays from the second costals droop downward to the level of the bottom of the calyx, and then, at about the top of the first palmars, they bend abruptly upward, and fold inward until the tips of the arms encircle the spiniferous summit of the disk, exposing the spines. The entire surface of the calyx is covered with irregular granules or vermicular markings.

Basals forming a slightly projecting, hexagonal disk, extending beyond the sides of the column; the suture lines distinct, but not actually grooved; axial canal small and sharply pentangular. Radials all hexagonal, owing to the straightness of the lower margins, and about once and a half as wide as long. First costals almost horizontal; wider than the radials and nearly as long; strongly inflected at the sides, and rounded exteriorly; the upper face semicircular in outline, and directed slightly downward. The succeeding brachials constitute a part of the free extensions, and face more or less downward. The second costals, which are a little smaller than the first, are touched by the interbrachials only at their lower ends, the lateral upper parts of the plates resting against rigid ambulacral plates. Distichals various in number, but as a rule the two posterior rays have one plate in each division, both axillary, and about as large as the second costals. They support at each side a large quadrangular palmar, which is followed by a smaller cuneate one, and this by two rows of extremely short

arm plates. Only the first palmars are in contact laterally, the others being free. In the three anterior rays only one of the distichals is axillary; the opposite one, being truncated, supports two or three more moderately large cuneate distichals, which are followed by the regular arm plates. Sometimes, but exceptionally, both distichals are truncate, and the ray has but two primary arms, while the other rays have three or four. The first branching of the arms generally takes place from the ninth to tenth double row of joints, the second and third from the tenth to fifteenth above. The bifurcations are given off at one side of the main arm, which generally has three bifurcations, sometimes, however, but two; they are widely divergent, and the side-branches rarely bifurcate again. Arms heavy throughout, tapering very little upward; at each bifurcation there is a small node, and the arms themselves are slightly inflated — a peculiarity by which they are readily recognized. Pinnules apparently small, their two or three proximal joints provided with small hooks. Anal plate considerably narrower than the radials. Interbranchials in two ranges; there being one and five at the regular sides, and three or two followed by five or six at the anal side. When there are three plates in the first row, the middle one is narrow and wedged in between the two at the sides, often barely touching the anal piece. The two outer plates of the second row at each side of the area curve outward in the direction of the free rays, and are largely interambulacral, touching but slightly the costals; the extended upper part resting against the covering plates of the ambulacra. Ventral disk from the top of the free rays to the base of the orals obconical, leaning a little to the anterior side; broadly conical above; the plates irregularly arranged, slightly convex, about equal in size. The orals occupy the truncated upper face of the disk; the posterior one is located in the centre between the orals at one side and the anal tube at the other; it is strongly nodose or subspinous; the other four orals are produced into long, very heavy spines, which either gradually taper to their extremities, or widen upward and fork at the top. Anal tube very short and stout, directed obliquely upward; the opening lateral, and surrounded by four or five acute spines of fully one half the length of those surmounting the orals. Ambulacra hidden by superimposed plates to the bases of the free rays, where those of the first and second order are represented by a single, strongly nodose plate. Column moderately strong, the nodal joints considerably widest, and angular at their margins; while the intervening ones are very short.

Horizon and Locality. — Lower Burlington limestone ; Burlington, Iowa, and Lake Valley, New Mexico.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — With the excellent material before us, we have attempted in vain to separate from this species *Actinocrinus planobasilis* Hall, *Actinocrinus quadrispinus* White, and *Amphoracrinus divergens*, var. *multiramosus* M. and W. We admit that in some of the specimens the radials and costals are comparatively shorter, the number and branching of the arms slightly different, and the surface ornamentation somewhat coarser or almost obsolete ; but these characters appear to be independent of each other. Nor can the forking of the oral spines, upon which Meek and Worthen proposed a variety, be considered a valid distinction, because it occurs as well in the smaller specimens of the type of *A. quadrispinus*, as in the typical form of *Amphoracrinus divergens*.

***Amphoracrinus viminalis* (Hall).**

Plate LIV. Fig. 8.

1863. *Actinocrinus viminalis* — HALL ; 17th Rep. N. Y. State Cab. Nat. Hist., p. 54, and 1875, Geol. Surv. Ohio, Palæont., Vol. II., p. 165, Plate II., Figs. 12 to 14.
 1881. *Amphoracrinus viminalis* — W. and SP. ; Revision Palæocr., Part II., p. 155.

Below medium size. In the form of the dorsal cup, style of ornamentation, as well as the general structure and mode of branching of the arms, resembling the preceding species. Dorsal cup depressed turbinate, the sides rapidly and uniformly spreading from the truncated base to the top of the costals, above which the brachials form free lobes, which droop to about the first bifurcation of the arms, leaving only the basals and radials visible from a side view. Plates almost flat, except for the general curvature, but owing to the rather deep grooves at the sutures they have the appearance of being slightly convex ; their surface obscurely granulated.

Basals forming a very short, subhexangular cup, which slightly projects over the sides of the column ; the interbasal sutures distinct but not grooved. Radials two thirds as long as wide, and as large as, or larger than, both costals together ; the lower sloping sides much longer than the corresponding upper ones. First costals quadrangular, three times as wide as long ; the second smaller than the first, broadly triangular in outline ; they are followed by 2×2 short, quadrangular distichals, which are connected laterally by

suture, and support the free arms. There are but two primary arms to each ray, which branch three or four times at irregular intervals, the first bifurcation taking place above the fifth to sixteenth double row of ossicles, the last a short distance from the tips. Arms divergent, rather stout, and tapering very little; they are cylindrical, and above the second plate biserial, the two proximal ones of the primary arms being cuneate. First interbranchials of moderate size, rising to the height of the second costals; the two plates of the second row are to a large extent interambulacral, touching the distichals but slightly at their lower ends. Anal plate a little longer than the radials, and nearly as wide; followed by three plates, of which the two outer ones are as large as the single plate of the regular sides, the middle one smaller and cuneate. The tegmen is not shown in any of the specimens, being covered by the arms, but apparently it had no spines, or the points would be visible at the ends of the arms.

Horizon and Locality. — Waverly group; Richfield, Summit Co., Ohio.

Types in the New York State Cabinet at Albany, N. Y.

***Amphoracrinus spinobrachiatus* (HALL).**

Plate LXII. Figs. 1, 2, 3, 4.

1860. *Actinocrinus spinobrachiatus* — HALL; Suppl. Geol. Rep. Iowa, p. 6.
 1873. *Amphoracrinus* (?) *spinobrachiatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 389, Plate 6, Figs. 5a, b, c.
 1881. *Amphoracrinus spinobrachiatus* — W. and SP.; Revision Palæocr., Part II., p. 155.
 Syn. *Actinocrinus inflatus* HALL; 1860, Suppl. Geol. Rep. Iowa, p. 20.
 Syn. *Amphoracrinus inflatus* — WHITFIELD; Mem. Amer. Mus. Nat. Hist. N. York, Vol. I., p. 22, Plate 2, Figs. 10, 11 (not *Actinocrinus* (*Amphoracrinus*) *inflatus* Hall, 1861, Boston Soc. Nat. Hist., p. 284 = *Agaricocrinus inflatus*).

Calyx subpyramidal, distinctly lobed; the dorsal cup shallow-saucer-shaped; almost flat, and in specimens with the arms preserved not visible from a side view. Ventral disk nearly as high as its width at the arm bases, inflated above the food grooves, and the lower part of the interambulacral spaces depressed. The plates of the dorsal cup thin, their surface covered with irregular, rather prominent rugosities, which are confluent, arranged in rows, and form transverse ridges. The ridges upon the radials are crescent shaped; those of the first costals straight, while those of the second costals and distichals are angular, their salient angles directed upwards, the ridges upon the interbranchials less distinct, and longitudinally arranged.

Basals forming a hexagonal, slightly projecting disk, which extends but

little beyond the sides of the column; column facet concave. Radials once and a half as wide as long, the sides rapidly spreading. First costals fully as wide as the radials, but considerably shorter, subquadrangular in outline, but generally hexangular. Second costals a little longer than the first, and directed slightly downward, as also the distichals. Distichals nearly as large as the second costals, and all axillary, supporting upon each side two moderately large palmars, which are laterally connected and support the free arms, of which there are four to the ray. Arms simple, long, heavy, rounded in the lower portions, flattened and wider in the upper; the tips incurving. The two proximal arm plates cuneate, the two rows of ossicles succeeding them moderately long, and every sixth one extended into a sharp lateral spine. The spines increase in length upwards, commencing as small nodes, and attaining at the upper part of the arms a length of 2 or 3 mm., the corresponding ones placed opposite. First interbrachial comparatively small, higher than wide, followed by two rather large plates in the second row, and one or two smaller interambulacral pieces at each side. Anal plate remarkably small, only half as wide as the radials, supporting two plates, which are followed by three large and two smaller ones at the sides, the latter bending outward, helping to form the free rays. Plates of the ventral disk slightly convex, their surface covered with small pustules without definite arrangement. Orals a little larger than the other plates, and formed into short spines; the posterior one placed at the side of the anal tube. Anal tube excentric and very short, directed obliquely upward. No ambulacral plates are visible to the base of the free rays, where those of the first and second order are represented by single plates. Column composed of rather long joints; the nodal ones considerably widest and rounded along the margin; the axial canal small and pentagonal.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa, and Lake Valley, New Mexico.

Remarks. — This species is readily distinguished from all others by its arm structure.

Type in the (Worthen) Illinois State collection at Springfield.

PHYSETOCRINUS M. and W.

1869. MEEK and WORTHEN (Subgenus of *Strotocrinus*); Proceed. Acad. Nat. Sci. Phila., p. 158; also 1873, Geol. Rep. Illinois, Vol. V., p. 349.
 1881. W. and SP.; Revision Palæocr., Part II., p. 155 (Proceed. Acad. Nat. Sci. Phila., p. 329).
 1889. S. A. MILLER; North Amer. Geol. and Palæont., p. 269.

Arrangement of the plates up to the distichals as in *Actinocrinus*; but the anus located within the tegmen, not at the end of a tube. The calyx distinctly lobed. The arms arranged in groups, and given off from the two main divisions of the rays alternately from opposite sides. But, contrary to the case in *Actinocrinus*, each order of brachials, from the costals up, consists of but a single plate, which is axillary, and supports on one side an arm and upon the other a brachial of a higher order. Arms biserial. Interbrachials numerous, and in contact with the plates of the disk. Ventral disk depressed at the summit, plicated around the margin, and generally composed of small, irregular pieces. Anus excentric. Column round.

Distribution. — Only known from the Burlington group in America, but it apparently occurs also in the Mountain limestone of Ireland.

Type of the genus: *Physetocrinus ventricosus*.

Remarks. — Zittel makes *Physetocrinus* synonymous with *Strotocrinus*, and the latter a subgenus of *Actinocrinus*.

Physetocrinus ventricosus (HALL).

Plate LXIII. Fig. 6, and Plate LXIV. Figs. 1, 2, 3, 4, 5, 6, 7, and 8a, b.

1858. *Actinocrinus ventricosus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 595, Plate 11, Figs. 6a, b.
 1873. *Physetocrinus ventricosus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 349.
 1881. *Physetocrinus ventricosus* — W. and SP.; Revision Palæocr., Part II., p. 157.
 Syn. *Actinocrinus subventricosus* MCCHESENEY; 1860, New Pal. Foss. p. 21 also 1869, Chicago Acad. Sci., Vol. I., p. 16, Plate 4, Fig. 6.
 Syn. *Physetocrinus subventricosus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 349.
 Syn. *Actinocrinus ventricosus* var. *cancellatus*, HALL; 1861, Prelim. Descr. Pal. Foss., p. 3.
 Syn. *Actinocrinus ventricosus*, var. *internodius* HALL; 1861 Bost. Journ. Nat. Hist., p. 278.
 Syn. *Actinocrinus ventricosus*, var. *reticulatus* HALL; *ibid.*, p. 279.

Of more than medium size. Calyx generally as wide as high, somewhat higher in young specimens. Dorsal cup basin-shaped; the sides convex below, more rapidly spreading from the top of the distichals; the arm bases projecting, deeply grooved between the rays and their main divisions, and slightly between the individual arms. Ventral disk hemispherical, varying

from one third the height of the calyx in large specimens to scarcely one fourth in smaller ones. Plates of the cup convex and of rather uniform size; their surface ornamentation exceedingly variable. In most specimens, the middle part is bare of all markings, but along the margins of the plates there are at each side from one to three elongate processes or short ridges, and between them along the suture lines deep pits, which almost penetrate the test. In other specimens there are continuous ridges covering the whole surface, which give to the plates a reticulate or cancellate appearance; while in still others rows of bead-like elevations take the place of the ridges.

Basals forming a low, cylindrical cup, which is somewhat grooved at the sutures. Radials and costals of nearly the same size, and all as long as wide; the first costal a little smaller and hexangular, the second heptangular. Distichals 1×10 , about half the size of the axillary costals, and all axillary; the higher orders of brachials much smaller, and rounded like arm plates; the bifurcation being alternately from every successive plate. There are generally two or more orders above the palmars, sometimes three, and in young specimens occasionally but one; the number of arms, therefore, varies from four to six in the main branches, and from eight to twelve in the ray. Arms given off alternately from opposite sides, and the proximal one free above the second plate, the others above the first; they are below medium size, long, and rounded on the back. Pinnules covered with small hooks. Regular interbrachials from eight to ten, in six or seven ranges. Anal plate as large as the radials; followed by 2, 3, 3, 3, 4 and two plates. Interdistichals two or three. Interbrachials as well as the interdistichals in contact with the plates of the disk. Ventral disk deeply plicated around the margin; the plates small, generally smooth, and of nearly the same size and form. Column of nearly uniform size to about 6 cm. from the distal end, where it gives off strong branches at irregular intervals, and tapers gradually to a sharp point. The nodal joints are a little the longest and widest near the calyx, but become indeterminate farther down; axial canal of moderate size.

Horizon and Locality.—Upper and Lower Burlington limestone; Burlington, Iowa, and at several localities in Missouri.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks.—This species has been divided up into several varieties, based upon certain variations in the ornamentation of the plates, which cannot be recognized in large collections; and McChesney described a young specimen as a new species. As a rule, in the smaller specimens the tegmen is more

depressed, and the dorsal cup more elongate proportionally. This is also the case with the specimens from the Lower Burlington bed, the calyx being one fourth higher than wide, and the specimens have but six arms to the ray, but are in other respects identical with those from the Upper bed.

***Physetocrinus dilatatus* (M. and W.).**

Plate LXIV. Figs. 9, 10.

1869. *Strotocrinus* (*Physetocrinus*) *dilatatus* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 162. Also 1873, Geol. Rep. Illinois, Vol. V., p. 363, Plate 10, Fig. 6.
 1881. *Physetocrinus dilatatus* — W. and SP.; Revision Palæocr., Part II., p. 157.

Calyx moderately large, the cup saucer-shaped, rapidly expanding from the basals to the top of the distichals, and more rapidly thence to the free arms, which at their bases are directed almost vertically, and owing to their large size are much crowded. Plates of the dorsal cup slightly convex, with shallow indentations at the angles of the plates.

Basals short, not thickened or expanded below; axial canal large. Radials and costals nearly of uniform size, a very little wider than long. Distichals almost as large as the costals, and of similar form; they support an arm, which is free beyond the second plate, and a palmar, which either supports two arms, or a single arm and an axillary post-palmar. The arms thus vary from six to eight to the ray; they are very stout, increasing in thickness from their bases up until their size is almost doubled at about two inches from the calyx. Regular interbrachials: 1, 2, 2, 2, 2, 1. Anal plate a little shorter than the radials; followed by 2, 3, 3, 4 and two plates. Interdistichals two to three. Ventral disk low-hemispherical, slightly plicated around the margin; the plates small, irregularly arranged, and of about the same size. Anus excentric, at the top of a small protuberance.

Horizon and Locality.—Upper Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks.—This species is readily distinguished by the flatness of its calyx and its stout arms.

Physetocrinus asper (M. and W.).*Plate LXIII. Figs. 7a, b.*

1869. *Strotocrinus (Physetocrinus) asper* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 181; also Geol. Rep. Illinois, Vol. V., p. 351, Plate 7, Figs. 1a, b.
1881. *Physetocrinus asper* — W. and SP.; Revision Palæocr., Part II., p. 157.

Calyx moderately large, higher than wide. Dorsal cup obconical, with nearly straight sides, gradually expanding to the top of the distichals, the higher brachials curving obliquely outwards. Ventral disk highly elevated, hemispherical, occupying fully one third the height of the calyx. Plates of the cup convex, covered with one or more rather large, angular protuberances of irregular form and size, some of them round, others elongate, and some transversely arranged, others longitudinally.

Basal cup broad, nearly three times as wide as long, not thickened at the lower margin, deeply notched at the sutures, and presenting a trilobate outline from a dorsal aspect. Radials wider than long, and as large as the two costals together, which are of nearly equal size, and almost twice as wide as long. Arms ten to the ray, five from each subdivision; all free above the axillaries. Anal plate narrower than the radials, supporting ten or eleven plates in five rows. The regular interbrachials consist of about eight pieces, which connect with the plates of the disk. Ventral disk inflated; composed of irregular, flat pieces of moderate size. Anus subcentral, at the top of a small protuberance. Column small, round, the four or five proximal joints subequal.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks. — This species differs from all others of the genus in the form of the calyx, and its style of ornamentation.

Physetocrinus ornatus (HALL).*Plate LXIII. Figs. 1, 2, 3, 4.*

1858. *Actinocrinus ornatus* — HALL, Geol. Rep. Iowa, Vol. I., Part II., p. 583, Plate 10, Fig. 12.
 1873. *Physetocrinus ornatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 349; also W. and SE., 1881, Revision Palæocr., Part II., p. 157.
 Syn. *Actinocrinus senarius* HALL; 1860, Suppl. Geol. Rep. Iowa, p. 25.
 Syn. *Actinocrinus Brittsi* — S. A. MILLER; 1892, Adv. Sheets 18th Rep. Geol. Surv. Indiana, p. 36, Plate 6, Figs. 1-4.

Calyx of medium size, depressed bowl-shaped to the top of the costals, thence spreading abruptly to the arm bases; the distichals and palmars longitudinally rounded and laterally inflected so as to form at the arm regions, between the rays and their subdivisions as well, deep grooves, which give to the calyx, as seen from above or below, a distinctly lobed outline. Ventral disk but very slightly convex. Plates exceedingly thin and delicate, beautifully ornamented with angular, well defined ridges, passing from plate to plate and meeting at their centres; those running up and down the radials and brachials the strongest, and dividing the surface of the dorsal cup into five nearly equal fields.

Basals very small, represented by a short dentate rim, which slightly projects beyond the column. Radials wider than long. First costals hexagonal; the second equal to, or larger than the first. Distichals somewhat smaller, the interspaces deeply depressed and occupied by one or two small interdistichals; giving off an arm from one side, which is free from above its first plate, and a palmar from the other. The latter supports the second arm and a post-palmar, which in turn gives origin to two arms, there being four arms in each main division, and eight to each ray. Arms moderately thin, somewhat flattened in their upper portions. Pinnules composed of very long joints, bearing a small hook near the outer end. Regular interbrachials: 1, 2, 2, 2; those of the second range almost as large as that of the first row, the two upper ones minute and on a level with the arm bases. Anal plate a little smaller than the radials, supporting 2, 3, 3, 2 plates. Interbrachials at all five sides in contact with the plates of the tegmen, as are also the interdistichals. Ventral disk deeply grooved near the arm bases, which gives to the surface a plicated aspect; it is composed of very small pieces, which are flat and quite irregular at the middle of the disk, but near the outer margins, where the small covering pieces of the ambulacra are exposed,

their arrangement is regular, and the plates nodose. Orals cannot be recognized. Anus excentric, slightly raised above the general surface of the disk; the opening directed anteriorly, although occupying the posterior side of the disk. Column composed of rather short joints, the nodals a little the widest; axial canal moderately small.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa, and Sedalia, Mo.

Remarks. — *Actinocrinus senarius* was described from a specimen of this species in which the last bifurcation in the calyx is broken away, and which was supposed to have but six arms to the ray.

Physetocrinus Copei (S. A. MILLER).

Plate LXIII. Fig. 5.

1881. *Actinocrinus Copei* — S. A. MILLER; Journ. Cincin. Soc. Nat. Hist., Vol. IV. (Decbr. number), Plate 7, Figs. 2a, b, c.

1885. *Physetocrinus Copei* — W. and SP.; Revision Palæocr. Part III., p. 113.

Nearest to *Physetocrinus ornatus*, but with fewer and larger plates, and the calyx proportionally higher; height and width as seven to eight. Sides of the dorsal cup evenly spreading from the foot of the basals to the top of the costals, and thence more rapidly to the arm bases, where the interspaces between the rays are deeply depressed. Ventral disk hemispherical, occupying about one third the height of the entire calyx. Plates of the dorsal cup a little convex, covered with well defined ridges, meeting in the centre of the plates and running to adjoining ones. There are three ridges between the radials and basals, and two from one radial to another, which together form concentric triangles. The ridges between the other plates are single, but within the corners of their triangles there are angular nodes, which are sometimes connected and also form triangles.

Basals short, their lower margins somewhat projecting outward and crenulated at the edges; interbasal suture lines slightly grooved. Radials as long as wide. Costals nearly as wide as the radials, but one third shorter; the first hexagonal, the second heptagonal. Distichals and palmars smaller in proportion, both angular on the back; the latter supporting the arms, of which there are four to the ray. Arm facets large. Regular interbrachials: 1, 2, 2, 2, very gradually decreasing in size. Anal plate usually a little smaller than the radials; followed by 2, 3, 3 and 3 plates. Interdistichals one, elongate. Ventral disk plicated around the margin; the surface of the

plates beautifully granulated. Interambulacral plates flat. Orals crowned with a small central tubercle, as are also the plates roofing the ambulacra, which are irregularly arranged, and decrease in size as they approach the arms.

Horizon and Locality. — Lower Burlington limestone; Lake Valley, New Mexico.

Type in the collection of Prof. Cope.

Physetocrinus lobatus W. and Sr. (nov. spec.).

Plate LXIII. Figs. 8a, b.

Calyx proportionally higher than in the preceding species, height to width as ten to nine; distinctly lobed at the arm regions. Dorsal cup somewhat bulging, slightly constricted across the distichals. Ventral disk almost flat; interradial and interdistichal spaces — the latter from near the summit of the disk to the second row of interbrachials — deeply grooved, giving to the surface of the tegmen, and to the upper part of the cup a sharply lobed outline. Ornamentation of the plates similar to that of *P. Copei*; but the ridges, as a rule, more prominent, the inner faces of the triangles deeper, and all enclosing a second triangle within the outer one.

Basals moderately short, forming a cup with slightly projecting lower margin, and small notches at the sutures; axial canal small and pentangular. Radials and costals as long as wide, or a little longer; the first costal two thirds the size of the radials and hexangular, the second somewhat larger than the first, and heptangular. Distichals and palmars small, both even with the costals, but raised considerably above the interradial spaces. The distichals give off an arm to the outer sides of the rays, the palmars two arms, making six to the ray. Structure of the arms unknown. Regular interbrachials: 1, 2, 2, 2; the anal plate followed by 2, 3, 3, 2 plates; the upper row at all sides in contact with the plates of the tegmen. Plates of the disk almost flat, small, and of uniform size; their arrangement irregular, except on approaching the arms, where they become alternate. Orals indeterminate, and probably wanting. Anal regions slightly bulging, the opening directed anteriorly.

Horizon and Locality. — Lower Burlington limestone; Lake Valley, New Mexico.

Types in the collection of Wachsmuth and Springer.

CACTOCRINUS W and SP. (nov. gen.).

(Κάκτος a thorny plant, κρίνον a lily.)

Calyx generally longer than wide, the ventral disk high, conical, passing gradually into a strong, almost central tube. The plates of the cup ornamented by radiating ridges and nodes. Basals three, comparatively short. Costals two, generally hexagonal and heptagonal. Distichals 1×10 , all axillary. The succeeding orders of brachials, when present, also consist of a single row of plates, but only one plate at each side of the ray is axillary; the other one is truncated, and gives off an arm which is free from the second or third plate; the axillary supports either two simple arms, or one from one side and two from the other, the arms being given off alternately from opposite sides like the pinnules. Arms equidistant or nearly so, long, biserial and infolding; back and sides generally covered with nodes or thorns, and the pinnules with sharply pointed hooks. The pinnules are in close contact, and those of one side of the arm are placed with their ventral faces fronting those from the opposite side. They are composed of numerous elongate joints, which, with the exception of the three or four distal ones, are produced into sharp, prominent hooks, directed obliquely upward and outward, and arranged in rows parallel to the sides of the arms. The hooks of one pinnule curve over the back of the adjoining one, so as to give to the mass of pinnules, in their dorsal aspect, the appearance of a fine network in which their outlines cannot be distinguished. The ventral furrow is covered by two rows of side pieces, which enclose two rows of minute covering plates. Interbrachials numerous, separated from the interambulacrals by the upper row of fixed brachials, which are in contact laterally. The plates of the ventral disk are more or less spinous, and so irregular in their arrangement that it is often difficult to identify the orals and radial dome plates. Anal tube very long and almost central. Column large; the axial canal pentangular.

Type of the genus: *Cactocrinus proboscidalis* (Hall).

Distribution.—Restricted in America to the age of the Kinderhook group and Lower Burlington limestone, with a single aberrant survivor in the Upper Burlington beds. The genus may possibly be represented in Europe in the Mountain limestone of Ireland; but, so far as we know, not in Belgium, nor in the Yorkshire beds of England.

Remarks. — The various species which we refer to this genus were, with a single exception, originally described under *Actinocrinus*; but Meek and Worthen, as we have already stated, placed them in a section by themselves. The arms of these species are given off in a continuous row around the calyx proper, and the bifurcation is on successive brachials beyond the distichals; while in *Actinocrinus* the calyx is more or less distinctly lobed, the arms are given off in clusters, with large plates interposed between the rays, and the bifurcation is on every second or third brachial. The structure of the pinnules also is essentially different in the two groups.

In one very frail specimen of *Cactocrinus proboscidalis*, we were enabled to examine the structure of the pinnules on all sides. At some places on the ventral side the covering plates and side pieces were removed, and beneath was exposed the floor of the food grooves, formed of two rows of small transverse pieces, alternately arranged, and in a somewhat sloping position. The structure is well shown by Mr. Westergren's excellent figures on Plate LVIII, Figs. 7a, b, c, d.

McChesney's *Actinocrinus hurdianus* and *A. Fosteri* also belong to this genus, but we are unable to identify the species from the descriptions and figures. The types were lost in the Chicago fire.

***Cactocrinus proboscidalis* (HALL).**

Plate LVIII. Figs. 3, 4, 5, 6, 7a, b, c, d.

1858. *Actinocrinus proboscidalis* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 584, Plate 10, Fig. 13.
 1881. *Actinocrinus proboscidalis* — W. and SP.; Revision Palæocr., Part II., p. 145.
 Syn. *Actinocrinus quaternarius* — HALL; 1860, Suppl. Geol. Rep. Iowa, p. 22, and Whitfield 1893; Mem. Am. Mus. Nat. Hist. N. York, p. 7, Plate 1, Figs. 1-3.
 Syn. *A. excerptus* HALL; 1861, Descr. New Spec. Crin., p. 3; also Boston Journ. Nat. Hist. p. 276.
 Syn. *A. quaternarius*, var. *spiniferus* HALL; 1881, Descr. New Spec. Crin., p. 11.
 Syn. *A. themis* HALL; 1861, *ibid.*, p. 11.
 Syn. *A. lagena* HALL; 1861, *ibid.*, p. 13.
 Syn. *A. dalyanus* S. A. MILLER; 1881, Journ. Cincin. Soc. Nat. Hist., Vol. IV., Plate 7, Figs. 1, 1a.

Calyx subovate, more or less truncate at the base. Ventral disk almost as high as the dorsal cup, very gradually passing into the anal tube. Plates of dorsal cup delicate, traversed by a single row of sharp, well defined ridges, running from the edges of the plates to the centre, where they form conspicuous nodes, which upon the radials and brachials are transversely elongate, but upon the interbrachials are subcircular and angular.

Basal cup short, slightly spreading, excavated at the bottom; the interbasal sutures deeply grooved. Radials larger than the costals, a little wider

than long. First costals larger than the second, quadrangular or pentangular; the second pentangular or heptangular. Distichals one, axillary, supporting within the calyx two single palmars, followed by the free arm plates, which from the second piece are arranged in double rows. Arms crowded, long and heavy; their upper ends rapidly tapering to a fine point; the plates somewhat transversely angular, and the suture lines parallel. Pinnules in close contact, composed of about fifteen joints, from two and a half to three times as long as wide; all, with the exception of the three upper ones, provided with a prominent, sharp hook, directed obliquely upward, and arranged longitudinally in rows parallel with the sides of the arms. Regular interbrachials: 1, 2, 1; large specimens have an additional row of two plates, and the second palmars take part in the calyx; the palmars of adjacent rays in contact laterally. The first anal plate is followed by three to five interbrachials, there being no higher anals, and the species has no interdistichals. Ventral disk conical, composed of rather large, spinous or nodose plates, separated by small, convex pieces. The plates are irregularly arranged, and the orals and radial dome plates are with difficulty recognized; the posterior oral is erect, and forms a part of the anal tube. The tube, which extends considerably beyond the limits of the arms, is composed of convex pieces; it tapers gradually, and is quite slender at the upper end. Column strong, composed near the calyx of alternate thick and thin joints with rounded edges; the former increase in diameter downwards, while the latter grow narrower, gradually become cylindrical, and increase in number quite rapidly, there being already seven to the internode at 90 mm. from the calyx.

Horizon and Locality.—One of the characteristic fossils of the Lower Burlington limestone; Burlington, Iowa, Sedalia, Mo., and Lake Valley, New Mexico.

Remarks.—We regard Hall's *Actinocrinus quaternarius* and its variety *spiniferus*, his *A. excerptus*, *A. themis*, and *A. lagena*, as mere variations of this species, differing slightly in the matter of ornamentation. They cannot be separated in large collections, although they may seem to be quite distinct in individual specimens. Our study of the species is based upon over one hundred good specimens.

Cactocrinus lucina (HALL).*Plate LVI. Figs. 8, 9.*1861. *Actinocrinus lucina* — HALL; Prelim. Descr. New Palæoz. Crin., p. 11.1881. *Actinocrinus lucina* — W. and SP.; Revision Palæocr., Part II., p. 144.Syn. *Actinocrinus puteatus* ROWLEY and HARE; Kansas City Scient., July 1891, p. 101, Plate 2, Fig. 16.

A small species. Calyx biturbinate; the sides to the top of the costals very slightly convex, the distichals somewhat spreading. Plates a very little elevated, and covered with obscure radiating ridges.

Basals quite small, barely projecting over the sides of the column; the suture lines distinctly grooved. Radials and anal plate very little larger than the costals; the latter twice as large as the distichals, which support two arms, making four to the ray, with frequently an additional arm in each of the posterior rays. Arms delicate, three to four times as long as the height of the dorsal cup, uniserial to the fourth or fifth plate, flattening in their upper portions, and somewhat wider at midway than at either extremity. The distichals apparently consist of two pieces forming a syzygy, and another syzygy occurs between the first and second palmar, the lines of union at both places being much more obscure than between the other plates. The third, fourth, and occasionally the fifth palmar are long and cuneate, all above arranged in double rows. The free arm plates are thickened at their upper edges, and the sides distinctly serrated. Interbrachials at the regular sides five to six, at the anal side nine to ten. Ventral disk nearly as high as the dorsal cup, the plates very uniformly subspinous.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa, and Louisiana, Mo.

Remarks. — Hall described this species with five arms in the two posterior rays. What is supposed to be the type specimen in the Museum of Comparative Zoölogy, and two others, show four arms in all five rays; but in others the posterior rays have five. The form is intermediate between *C. proboscidalis* and *C. reticulatus*, differing from them in the smaller size of the arms; very probably it is a young stage of the latter, and should be made a synonym.

Cactocrinus thalia (HALL).*Plate LVI. Fig. 2, and Plate LVII. Figs. 12 and 13.*1861. *Actinocrinus thalia* — HALL; Descr. New Spec. Crin. (Prelim. notice), p. 13.1881. *Actinocrinus thalia* — W. and Sr.; Revision Palæocr., Part II., p. 146.Syn. *A. infrequens* HALL; 1861, Descr. New Spec. Crin. (Prelim. notice), p. 14.Syn. *A. nodosus* S. A. MILLER; Geol. Surv. Missouri, Bull. No. 4, p. 33, Plate 5, Fig. 7.

Of the type of *C. proboscidalis*. Dorsal cup obconical, nearly as high as wide, somewhat constricted below the arm bases. Plates convex, the surface covered with radiating ridges and conspicuous nodes. The ridges, which are rounded and not very strongly marked, passing out from near the centre of the plates to the sides, where they meet the ridges from adjoining plates. Three of the radials have three parallel ridges running toward the basals; the two others, those resting both upon a basal and the first anal plate, have only two, one toward each basal. The ridges between all other plates are single. The nodes, which occupy the middle of the plates, are rounded, broad, and heavy, rising abruptly from the general surface; those upon radials and brachials transversely arranged.

Basals moderately large, forming a spreading cup, provided at the lower end with a thickened collar. Radials as long as wide, distinctly angular at the lower end. Costals of nearly equal size, one third smaller than the radials, and both hexangular. Distichals and palmars one, about half the size of the costals, the plates of the upper row connected laterally. Arms very long and slender, four to the ray; composed of short, smooth plates. Interbrachials at the regular sides, 1, 2, 2, 1; at the anal side 2, 3, 3, 2; the anal plate as large as the radials. Interdistichals two, longitudinally arranged. Construction of ventral disk and form of anus unknown. Column comparatively small; axial canal large and pentangular.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa, and Sedalia, Mo.

Remarks. — This species is most remarkable for the heavy nodes upon the calyx plates. It differs from *C. proboscidalis* in the larger size and more conical form of the dorsal cup, the greater number of interbrachials, the presence of interdistichals, its longer and more slender arms, the size of the column, and the greater width of the axial canal.

Cactocrinus reticulatus (HALL).*Plate LVIII. Figs. 2a, b.*

1861. *Actinocrinus reticulatus* — HALL; Descr. New Spec. of Crin. (prelim. notice), p. 2, and Boston Journ. Nat. Hist., p. 269.
 1881. *Actinocrinus reticulatus* — W. and Sr.; Revision Palæocr., Part II., p. 145.
 Syn. *A. thoas* HALL; 1861, Descr. New Sp. Crin. (prelim. notice), p. 11.
 Syn. *A. locellus* HALL; 1861, *ibid.*, p. 15.

Nearly as large as the preceding species. Calyx sub-ovate; the dorsal cup a little higher than the ventral disk, obconical, spreading uniformly to the top of the distichals, thence abruptly to the arm bases; the plates convex, and ornamented as in *C. proboscidealis*. Basal cup trilobate, short, thickened at the lower margin, and projecting downward over the top of the column; interbasal sutures deeply grooved. Radials and costals decreasing in size upwards, the radials nearly twice as large as the second costals. Distichals and palmars in single rows, the latter projecting outward. Arms four to the ray, except in the two posterior ones, in which the palmars next to the anal side support two post-palmars, giving to these rays five arms, or twenty-two to the species. Arm facets large, subovate. Arms long, heavy, and but very slightly tapering; they are cylindrical in the lower portions, but flatten toward the tips, and are composed of two series of moderately long pieces, united by parallel sutures, and bordered by four longitudinal rows of sharp nodes, two of them occupying the sides, the two others the back. Regular interbrachials: 1, 2, 2, 1; the last, which rests between the palmars, sometimes unrepresented. Anal plate followed by 2, 3, 2 and 1 plate, the upper one separating the post-palmars. Ventral disk sub-conical, covered with well defined spines, irregularly arranged, some of them bi- and tri-partite, separated by smaller convex pieces. Anal tube central or nearly so, of moderate size, its length unknown. Column of medium size, composed near the calyx of alternate thick and thin joints, the former with undulating edges; axial canal rather large and pentangular.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the University Museum at Ann Arbor.

Remarks. — This species is readily recognized by its arm formula, its heavy and spine-bearing arms, and by the spinous plates of the ventral disk.

Under the name *Actinocrinus locellus*, Hall redescribed this species without the tegmen, and under *A. thoas* a specimen with the arms attached.

Cactocrinus reticulatus, var. **ovatus** (HALL).*Plate LVII. Fig. 11.*1861. *Actinocrinus ovatus*—HALL; *Descrip. New Palæoz. Crin.*, p. 10.

This form scarcely deserves the rank of variety. It differs from *C. reticulatus* in the more rounded form of the dorsal cup, and the less expansion of the arm bases; in the more depressed form of the ventral disk, its shorter spines, and in the ornamentation of the dorsal cup. The radials and costals are traversed by three parallel ridges, which pass into the basals, and generally terminate in denticulate nodes at their lower margins; the ridges between the interbrachials of first and second order, and toward radials and costals being double, all others single.

Horizon and Locality.—Same as last.

Cactocrinus denticulatus W. and SP. (nov. spec.).*Plate LVII. Figs. 5a, b.*

Calyx of medium size, abruptly spreading above the distichals; the surface ornamented by radiating ridges and nodes similar to those of *C. reticulatus*; the arms covered profusely with tooth-like projections.

Basals of moderate size, their lower margins projecting beyond the sides of the column. Radials as large as both costals together, wider than long, and covered with a conspicuous transverse node, from which the ridges pass out to all sides, there being three ridges to the basals and costals, and one to each interbrachial. First costals hexangular, smaller than the second, the latter heptangular. Distichals a little smaller than the costals. Palmars short, and narrower than the breadth of the arms; three of each ray truncated, giving off simple arms, the fourth axillary and followed by post-palmars. Arms crowded and their bases bending outward; normally five to the ray; long, very heavy, infolding, and of uniform thickness throughout, but flattening toward the extremities. They are composed from the second joint up of two series of moderately long, convex pieces, which are surmounted by two sharp elongate nodes. The nodes increase in length upward, arranged in longitudinal rows; two of them running along the sides of the arms, and the others along the middle, on each side of the median suture line, giving to the arms a somewhat angular outline. Pinnules pro-

vided with sharp spines from $1\frac{1}{2}$ to 2 mm. in length. Regular interbrachials: 1, 2, 2, and 1. The first anal plate supports 2, 3, and 3 plates, and probably two more in the upper regions. Of the ventral disk little is known, except that it was covered by spinous plates. Column preserved only to the extent of a few pieces, which show that the nodal joints near the calyx have sharp, distinctly crenulated edges, and that the intervening joints are narrow and evenly rounded.

Horizon and Locality. — Same as last.

Types in the collection of Wachsmuth and Springer.

Remarks. — Distinguished from *C. reticulatus* and allied species by the arm formula, and the surface structure of the arms.

***Cactocrinus opusculus* (HALL).**

Plate LVI. Figs. 5a, b.

1860. *Actinocrinus opusculus* — HALL; Suppl. Geol. Rep. Iowa, Plate 2, Fig. 6 (without description).

1861. *Actinocrinus opusculus* — HALL; Boston Journ. Nat. Hist., Vol. VII., p. 264.

1881. *Actinocrinus opusculus* — W. and SP.; Revision Palæocr., Part II., p. 144.

1893. WHITFIELD; Mem. Amer. Mus. Nat. Hist. N. York, p. 9, Figs. 6, 7.

In form and ornamentation closely resembling *C. thetis*, but the species is smaller, and differs essentially in the surface structure of the arms. Calyx higher than wide, attaining its greatest width at and above the arm regions; truncated at the base. The dorsal cup quite narrow to the top of the distichals, then spreading abruptly, and forming a short rim, somewhat similar to that of *Strotocrinus*, from which the ventral disk rises almost vertically to one third its height. Surface of plates convex, traversed by narrow ridges, which, passing from the centre of the plates, unite at the edges with those of adjoining plates.

Basals short, thickened at the outer margins, and indented at the suture lines; the lower surface deeply excavated; surface of the plates covered with coarse wrinkles. Radials and costals almost twice as wide as long, the former somewhat the larger. Distichals a little smaller than the costals. Palmars quite small; the two inner ones of each ray supporting two arms; the two outer but one. Arms thirty; long, incurving, rounded at the base, but almost perfectly flat above, and somewhat wider, the edges knife-like and distinctly serrated. The arm plates are transversely angular, arranged in parallel rows, each plate marked by a small node placed close to the median suture line. Pinnules similar to those of *C. clarus*, but less closely

packed, the joints longer, the spines more slender, and directed more nearly outward. Interbrachials in three rows; at the regular sides 1, 2, 1; at the anal side 2, 3, 2, sometimes with a small plate wedged in between the palmars, but generally the palmars are in contact laterally all around. Interdistichals 1 or 2, longitudinally arranged. Ventral disk high, convex; the orals and radial dome plates, which are represented by plates of a first, second, and third order, large and spinous; the interambulacrals not very numerous, smaller and convex. Anal tube central, large and long, extending beyond the tips of the arms, and composed of irregular scale-like plates. Column of medium side; axial canal rather small.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the University Museum at Ann Arbor.

Remarks. — In a very young specimen, evidently of this species, the brachials are free from above the distichals; the palmars and post-palmars are more elongate in proportion, and uniserial and cuneate to the third plate, resembling in their outlines the arm plates of certain *Poteriocrinidæ*. The biserial plates above are also proportionally larger than in the older specimens, but have already the characteristic ornamentation of this species.

***Cactocrinus limabrachiatus* (HALL).**

Plate LVIII. Figs. 9 and 10a, b.

1861. *Actinocrinus limabrachiatus* — HALL; Deser. New Spec. Pal. Crin., p. 2; also Boston Journ. Nat. Hist., Vol. VII., p. 268.

1881. *Actinocrinus limabrachiatus* — W. and SP.; Revision Palæocr., Part II., p. 144.

Calyx bell-shaped, one third higher than wide, the arm bases slightly projecting; the dorsal cup fully once and a half as high as the ventral disk. Surface of plates traversed by single series of angular ridges, continued from plate to plate, and meeting at the centres, where they form sharp nodes. Only the basals and radials are connected with one another by four or five parallel ridges.

Basals rather large for the genus, forming a spreading cup; the suture lines not grooved. Radials a little longer than wide, their sloping upper faces small. First costals short, quadrangular, rarely pentangular, the upper and lower margins convex; the second a little larger. Distichals and palmars smaller in proportion. Arms six to the ray, given off as in the preceding species, distinctly flattened on the back, the three or four proximal plates long and cuneate. Higher up, where the arms become biserial,

the plates of one series stand obliquely to those of the opposite one, the outer ends of the plates directed slightly downward. Each plate, close to the upper margin, is marked by a sharp, conspicuous transverse ridge, while the lower parts of the plates are beautifully corrugated. The transverse ridges, which somewhat resemble the teeth of a file, suggested the specific name. Pinnules long; the dorsal side of each joint armed with a sharp, curved spine. Regular interbrachials: 1, 2, 2. Anal plate followed by 2, 2, 2 plates, and these by two very minute pieces, placed within the arm regions. Interdistichals one, large. Ventral disk depressed conical, composed of comparatively few large plates, the centre of which is produced into a small slender spine. Anal tube moderately large, and almost central.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the University Museum at Ann Arbor.

Remarks. — Differing from all other Burlington species of this genus in the surface markings of the arms. The set of arms figured by Whitfield (Mem. Am. Mus. Nat. Hist. N. York, Plate 1, figs. 8 and 9) as of this species, in our opinion belongs to *Actinocrinus tenuisculptus* McChesney; they do not show the sharp file-like ridge of each joint, which is so characteristic of this species.

***Cactocrinus longus* (MEEK and WORTHEN).**

Plate LVII. Fig. 8.

1869. *Actinocrinus longus* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 156.

1873. *Actinocrinus longus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 345, Plate 8, Figs. 1a, b.

1881. *Actinocrinus longus* — W. and SP.; Revision Palæocr., Part II., p. 144.

A large and elongate species. Calyx to the base of the anal tube almost once and a half as high as wide. Dorsal cup somewhat shorter than its width across the arm bases, the sides a little convex. Plates rather thin, very slightly elevated, and in well preserved specimens ornamented with very fine, more or less obscure ridges, which in sets of from one to five pass from plate to plate. The basals, radials, and costals are traversed by five such ridges; five others proceed to adjoining radials and the anal plate, but only three from the costals and radials to the lower interbrachials, and from the costals to the distichals, while all the remaining plates have single ridges. The suture lines, except the basi-radial and interrarial ones, rarely observed.

Basals forming a shallow cup, the sides gradually expanding but not thickened; the upper margins distinctly angular. Radials large, fully as long as wide. Costals one half smaller, almost as wide as long. Palmars quite small, the two inner ones of each ray giving off two arms, the outer ones but one. Arm bases a little projecting, the facets moderately large and concave; arm openings arranged in groups, those of adjoining rays twice as far apart as those within the ray. Respiratory pores slit-like. Structure of the arms unknown. Regular interbrachials: 1, 2, 2, 1, succeeded by a small elongate piece, wedged in between the arm-bearing brachials; the first as large as the costals, those of the second row equal in size to the distichals. The anal plate, which is as wide at the bottom as near the top, is followed by 2, 3, 2, and 2 plates, the latter generally supporting two small elongate pieces, which are in contact with the interambulacrals. The interdistichal spaces are deeply depressed, and occupied by a single flat piece. Ventral disk subconical, gradually passing into the anal tube, which is almost central, and very stout. The disk, as well as the tube, is composed of an immense number of all sorts of plates; some of them are large and take the form of elongate nodes or small spines, others are smaller and have rounded nodes; while the smallest ones, which are interspersed profusely between the larger, are simply convex. Orals extremely excentric, small, and separated by small plates; the posterior one, which stands erect and bears a transverse node, takes part in the tube. Radial dome plates subspinous, irregularly arranged, and placed at some distance from the arm bases.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks. — Meek and Worthen's figure in the Illinois Report is somewhat misleading; the plates of this species are generally less convex, the suture lines almost obsolete, and the radiating ridges upon the plates more distinct than shown in that figure.

Cactocrinus ectypus MEEK and WORTHEN.*Plate LVI. Fig. 10.*

1869. *Strotocrinus ectypus* — M. and W.; Proceed. Acad. Nat. Sci. Phila., p. 159.
 1873. *Strotocrinus ectypus* — M. and W.; Geol. Rep. Illinois, Vol. V., p. 353, Plate 7, Fig. 5.
 1881. *Actinocrinus ectypus* — W. and Sr.; Revision Palæocr., Part II., p. 143.

Calyx elongate, subovate; the ventral disk one fourth shorter than the dorsal cup. Plates of the cup moderately convex, a little angular in the centre, their surface traversed by radiating costæ, which in sets of three pass from the middle to the sides of the plates, dividing their surface into numerous triangles, each of which includes another one, but more obscure.

Basals forming a slightly spreading cup, more than twice as wide as high, and with small nodes at the lower margin, one placed at the termination of each of the costæ. Radials about as wide as long, and nearly as large as both costals together. The second costal smaller than the first, and both wider than long. Distichals half the size of the upper costals. The outer palmars of each ray support a single arm, the inner ones two. Arms three to each main division, or six to the ray; their structure unknown. Anal plate longer than wide, followed by eight to ten plates, of which the two upper are small, and connected with the interambulacrals. Regular interbrachials: 1, 2, 2, 2, 1, the upper one separating the upper brachials of adjoining rays. Ventral disk subconical, slightly bulging, the summit passing gradually into the anal tube; the plates are rather large, more or less convex or tumid, and of uniform size. The posterior oral takes part in the anal tube, which is large and nearly central. Column apparently large; the nodal joints deeply dentate at their outer margins.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks. — The typical figure by Meek and Worthen is quite misleading, being made from a crushed and much distorted specimen. In plump specimens the calyx is not depressed, as described by those authors, nor do the upper rows of brachials curve out horizontally, but lie almost in a straight line with the radials and costals. The species has no connection with *Strotocrinus*, but somewhat approaches *Actinocrinus* in having the rays separated throughout their full length, but they are not lobed as in that genus.

Cactocrinus clarus HALL.*Plate LVII. Figs. 9 and 10, and Plate LVIII. Fig. 1.*

1861. *Actinocrinus clarus* — HALL; Descr. New Spec. Crin. (Prelim. notice), p. 2; also Boston Journ. Nat. Hist., Vol. VII., p. 277; N. Y. State Bull. Nat. Hist. (1872), Plate 3A, Figs. 24 and 25.
 1881. *Actinocrinus clarus* — W. and SP.; Revision Palæocr., Part II., p. 142.
 1893. WHITFIELD; Mem. Am. Mus. Nat. Hist. N. York, Vol. I., p. 8, Plate 1, Figs. 4 and 5.

Larger than any of the preceding species. Calyx once and a half as wide as high. Dorsal cup depressed subconical, broadly truncate at the base, evenly spreading to the top of the costals, and more abruptly thence to the arms. Ventral disk as high as the dorsal cup, somewhat expanded above the arm bases, giving to the calyx a top-heavy appearance; the anal tube rising gradually from the summit. Plates of the dorsal cup heavy, and elevated into strong angular nodes, which are either smooth or connected with each other by short, indistinct ridges, except the palmars and post-palmars, which are rounded off toward the sides, and separated laterally by deep grooves. Suture lines distinctly grooved.

Basals broad, rarely thickened at the lower margins, and projecting but little beyond the column; interbasal sutures well marked. Radials about once and a half as large as the costals, as long as wide. First costals considerably narrower; either quadrangular, pentangular or hexangular, the second often larger than the first. Distichals as wide as the costals, but shorter. Palmars a little narrower than the distichals, and twice as wide as long, their outer plates supporting a single arm, the inner one two with post-palmars, except in the two antero-lateral rays, in which only one of the palmars is followed by higher brachials. Arm facets large, equidistant, and directed horizontally. Arms twenty-eight, biserial from their origin, heavy, long, and in close contact; they bend at first outward, then gracefully upward, being rounded on the back, and showing no sign of flattening or decrease in width to near the tips, where they rapidly taper to a fine point. Arm joints arranged in parallel lines, quite short, and without ornamentation. Pinnules long, fringe-like, composed of twelve to fourteen joints, each one provided with a long, sharply pointed tooth-like projection, directed obtusely upward and outward, which overlaps the corresponding joint of the next pinnule above, their teeth forming raised lines parallel to the sides of the arms. Regular interbrachials: 1, 2, 1; the three lower ones

of nearly equal size, and as large as the first costals. Occasionally there is another small elongate plate between the arm bases, but more frequently this is absent, and the palmars are in contact laterally. Anal interradius formed of six to seven plates; the upper one very elongate, resting between the palmars. Interdistichals one. Ventral disk covered by numerous small and extremely irregular pieces, which enclose somewhat larger spinous plates, probably representing the orals, and radial dome plates of a first, second, and third order. Column large; axial canal very wide and obtusely pentangular; the joints are long, the third from the calyx wider and longer than the surrounding ones, in some specimens almost twice as wide, and having a knife-like edge.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the University Museum at Ann Arbor, Mich.

Remarks. — This species is well characterized by the form of the calyx, and by the smooth and heavy arms without nodes or spines. It was described by Hall as having six arms in each ray, which is certainly incorrect. We have examined seven specimens, in all of which the antero-lateral rays have but five arms, while the others have six.

***Cactocrinus obesus* KEYES (MS.).**

Plate LV. Figs. 9a, b.

A large species of the type of *C. clarus*, but more elongate, much more nodose, and having but four arms to the ray. Calyx once and a half as wide as high, broadly and sharply truncated at the base; the plates thick and heavy. Dorsal cup gradually expanding to the top of the distichals, then bending abruptly outward. The plates of the dorsal cup extremely heavy, highly elevated, and produced into rather sharp, round nodes, especially the radials, which are decidedly more prominent than the succeeding plates; the suture lines traversed by short, obscure ridges. Ventral disk high-conical, as high as the dorsal cup, its sides but very slightly convex; orals and first radial dome plates wedge-shaped, and produced into very long, sharp, broadly transverse tubercles, which stand out conspicuously (5 to 7 mm.) from the tegmen.

Basal cup short but wide, much wider than the column; sub-cylindrical; the lower end abruptly truncated, forming a sharply angular edge at the bottom; the suture lines not grooved. Radials a little wider than long,

once and a half as large as the first costals; the second costals a little smaller than the first, both nearly as long as wide; the former hexangular, the latter generally pentangular. Distichals nearly as large as the costal axillary, but the nodes shorter. Palmars two in the calyx, short, rounded, and both wedge-shaped, the narrower ends directed to the inner side of the ray. Arm facets very large; the ambulacral passage oblong; the respiratory pores proportionally small. Structure of arms not known, but, to judge from the size of the facets, as large as those of *C. clarus*. Anal side not observed, being covered by matrix. Plates of the ventral disk greatly varying; gradually increasing in size and prominence upwards, those nearest the arm bases being the smallest and least conspicuous. Posterior oral very large, erect, and forming a part of the base of the anal tube, its wedge-shaped prominences directed transversely outward. The four other orals a little smaller, and separated from each other, and from the posterior one, by small flat pieces. Anal tube extremely large, subcentral; composed at the base of very large and smaller pieces, the larger ones produced into wedge-shaped nodes, similar to those of the orals, but somewhat smaller, the others having a perfectly flat surface.

Horizon and Locality. — Lower Burlington limestone, Hannibal, Missouri.

Types in the Missouri Survey collection, and that of Wachsmuth and Springer.

Cactocrinus thetis HALL.

Plate LVI. Figs. 3 and 4.

1861. *Actinocrinus thetis* — HALL; Descr. New Spec. Crin. (Prelim. notice), p. 11.

1893. WHITFIELD; Mem. Am. Mus. Nat. Hist. N. Y., Vol. I., p. 6, Plate 1, Fig. 10.

Syn. *Actinocrinus securus* HALL; Descr. New Spec. Crin. (Prelim. notice), p. 14.

This species is remarkable for the uniformity of its plates, which decrease but little upward. It is of the type of *C. clarus*, but smaller, the plates less robust, and it has six arms to each ray in place of five in the antero-lateral rays. It also approaches *C. opusculus* in the calyx, but that differs in having flattened and highly ornamented arms. Dorsal cup nearly once and a half as wide as high, broadly truncate at the base, uniformly spreading to the top of the distichals, and thence abruptly to the arms. Plates slightly convex, covered with fine, obscure ridges, with or without central nodes.

Basals short, their lower margins crenulated, slightly projecting beyond the sides of the column; the suture lines distinct but not notched. Radials

and costals of nearly the same size, and all a little wider than long; the distichals of the same form, and but slightly smaller; the palmars about half the size of the distichals. The outer palmars of each ray support an arm, the inner ones two small post-palmars and two arms. Arms crowded, long, rather heavy throughout, rounded on the back, their upper parts incurving, their proximal ends bending almost horizontally outward. Interbrachials five at the regular sides: 1, 2, 2; and there are 2, 3, and 2 above the anal plate. Some specimens have an additional narrow piece wedged in between the palmars. Interdistichals one. Ventral disk conical, slightly expanding near the arm bases, then rising evenly, and passing insensibly into the anal tube. The plates close to the arm regions are very small and almost flat, higher up larger and nodose plates are interposed between smaller ones, and at the foot of the anal tube all the plates are large and sharply nodose. Anal tube long, extending beyond the arms; composed of rather large, convex pieces, which decrease in size with the tube.

Horizon and Locality.—Same as last.

***Cactocrinus sexarmatus* (HALL).**

Plate LV. Figs. 10 and 11.

1860. *Actinocrinus sexarmatus* — HALL; Suppl. Geol. Rep. Iowa, p. 21 (not Bull. I., N. Y. State Mus. Nat. Hist., 1872, Plate 3A, Fig. 26 = *Cactocrinus extensus* W. and SP.).
 1881. *Actinocrinus sexarmatus* — W. and SP.; Revision Palæocr., Part II., p. 145.

Readily distinguished from the other species of this genus by the form of the calyx, which is biturbinate; the arm bases are not spreading, and the arm openings directed obliquely upwards. Dorsal cup deeply bowl-shaped, truncate at the base, the sides slightly convex below, and straight above. Plates but little elevated, their middle portions flat and perfectly smooth; but they are connected with adjoining pieces by short, prominent ridges, which form deep, trigonal pits at the angles of the plates.

Basals trilobate, short but wide, and somewhat spreading outward; the lower surface a little excavated for the reception of the column, which occupies about half its diameter. Radials very large, nearly as long as wide, and nearly as large as both costals together. First costals hexagonal, one fourth wider than long; the second about the same size as the first, but heptagonal. Distichals, palmars, and post-palmars rapidly decreasing in size upward, the first post-palmars elongate and semi-free. Arms six to the ray, the outer palmars of the rays being axillary. The structure of the arms is

not known, but they must have been quite delicate. Regular interbranchials: 1, 2, 2, 2, 1; the upper one narrow and entering the disk. Anal plate narrower than the radials; followed by 2, 3, 3, 2, and 2 plates. Interdistichals one. Ventral disk hemispheric to low-conical; the anal tube subcentral, moderately small, rising abruptly from the tegmen. Plates of the ventral disk proportionally large, and convex.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the (Worthen) Illinois State Collection, Springfield.

Remarks. — The specimen with arms figured by Hall in the Bulletin of 1872 is totally different from the type in the Worthen collection at Springfield. In the former the arm-bearing plates are horizontal; while in the latter they do not expand at all, and the arms were evidently quite delicate. Hall describes the anterior side of the type specimen as extending out more prominently, and he regards this as possibly of specific value. This prominence, however, occurs in the left posterior ray, and not in the anterior one, and is incidental, and not of structural importance.

***Cactocrinus extensus* W. and Sp. (nov. spec.).**

Plate LVII. Figs. 6, 7.

(Figured by Hall, 1872, in Bull. I., New York State Mus. Nat. Hist., as *Actinocrinus sexarmatus*.)

Closely allied to *C. thetis*, but smaller and the plates more nodose. Dorsal cup gradually spreading to the top of the costals, thence rapidly, almost horizontally, to the base of the free arms. The plates of the rays rising into transverse, angular tubercles, with obscure striæ. Interbranchials and interdistichal spaces deeply depressed; the plates of the former covered with round nodes.

Basals short, forming a slightly projecting, trilobate disk, deeply indented at the suture lines, and excavated on the bottom; axial canal small and pentangular. Radials larger and more prominent than the costals, once and a half as wide as long. The two costals of equal size, both narrower than the radials. Distichals as large as the costals; all axillary. Palmars considerably smaller, the inner ones axillary and supporting two arms, the outer ones a single arm. Arm openings thirty, almost equidistant. Arms rather heavy and closely packed; they pass out almost horizontally from the calyx, then curve upward, infolding at the tips. Interbranchial spaces: 1, 2, 1, and a minute piece on a level with the arm bases. Anal plate succeeded by 2, 2,

and 1 plate. Ventral disk conical, almost as high as the dorsal cup; gradually passing into the anal tube. The plates of the disk grow smaller as they approach the arm bases; the orals and radial dome plates larger and strongly nodose; the intervening smaller ones slightly tumid. Anal tube stout and long, extending considerably above the tips of the arms, and composed of small, tumid plates. The joints of the stem vary considerably in width; some of the nodal joints in the upper part are nearly three times as wide as the internodals, and are provided with knife-like edges, while the edges of the internodals are but very little convex.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Types in the collection of Wachsmuth and Springer.

Cactocrinus multibrachiatus HALL.

Plate LVI. Fig. 6 and 7, and Plate LVIII. Fig. 8.

1853. *Actinocrinus multibrachiatus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 580, Plate 10, Fig. 10.

1881. *Actinocrinus multibrachiatus* — W. and SP.; Revision Palæocr., Part II., p. 144.

Syn. *Actinocrinus multibrachiatus* var. *echinatus* HALL; Descr. New Spec. Crin., p. 10.

Calyx gradually and evenly spreading to the bases of the free arms, distinctly truncated at the lower end, and slightly depressed between the rays at the arm regions. The ventral disk fully one third lower than the dorsal cup, and surmounted by a moderately large, almost central tube. Plates of the dorsal cup all marked by strong radiating ridges proceeding to the sides of the plates, and meeting in the centre, where they form a conspicuous angular node, which is transverse upon the radials and costals. The ridges passing up and down the radials and brachials are more prominent than any of those proceeding to, or coming from, the interbrachials. Between the radials and basals there are three such ridges, or four where the former rest upon two basals, while the other plates have but one to each side.

Basals short, their lower margins projecting outward, forming a sharp rim, which extends beyond the sides of the column, and is deeply notched at the sutures. Radials nearly as long as wide. First costals one third smaller than the radials, three of them hexangular, the two posterior ones generally pentangular; second costals a little smaller than the first. Distichals still smaller, and all axillary; the outer ones supporting an arm, which is free from the second or third plate; the inner ones two palmars, of which again the inner one in both divisions of the ray is axillary, and supports two arms; the outer one is truncated, and followed by one arm; all arm-bearing plates

slightly projecting outward. Arm openings almost equidistant, the respiratory pores small. Arms eight to the ray, when normally developed, but rays with seven or even six arms occur quite frequently; they are somewhat flattened, and composed of two series of transverse, rather short and apparently smooth pieces. Regular interbrachials: 1, 2, 2, 1 in mature specimens; the first the same size as the first costals, the upper one very narrow, and wedged in between the upper row of brachials. Anal plate followed by 2, 3, 2, and 1 plate. Ventral disk depressed conical, the plates near the summit rather large and sharply nodose, those near the arm bases somewhat smaller. Anal tube long, moderately thick, composed of short, transverse pieces, with sharp, projecting edges. Column of medium size, the joints rather short, the nodal ones distinctly angular and slightly projecting.

Horizon and Locality.—Lower Burlington limestone; Burlington, Iowa.

Type in the (Worthen) Illinois State collection.

Remarks.—Approaching *C. cœlatus* in the form and ornamentation of the dorsal cup, but the tegmen of that species is comparatively higher, more conical, and the plates of the anal tube are larger and more nodose.

***Cactocrinus cœlatus* HALL.**

Plate LIX. Figs. 8, 9.

1858. *Actinocrinus cœlatus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 585, Plate 10, Figs. 14a, b.

1881. *Actinocrinus cœlatus* — W. and Sp.; Revision Palæocr., Part II., p. 143.

Larger than the preceding species. Calyx short-subfusiform and highly ornamented. Dorsal cup one fourth wider than high; uniformly spreading from the basals to the top of the arm-bearing brachials. Ventral disk subconical, almost as high as the cup, the upper part drawn out, and passing imperceptibly into the anal tube. The cup ornamented as in *C. multibrachiatus*, except that the costals are connected among themselves and with the radials by three parallel ridges, in place of one, as in that species.

Base short; the sides neither spreading upward, nor projecting on the lower margin; the lower surface sufficiently excavated to enclose the first stem joint; interbasal sutures distinctly grooved. Radials a little wider than long, and much larger than the costals. The higher brachials arranged as in *C. multibrachiatus*. Arms eight to the ray, slender; gently curving at their bases outward and upward; the tips, so far as observed, not incurving,

but somewhat decreasing in width; moderately flattened on the back, but without surface markings; the sides slightly dentate. The spines of the pinnules rather short. Interbrachials: 1, 2, 2, 1, the first a little larger than the costals. The anal plate, which is generally narrower than the radials, supports 2, 3, 2, and 1 piece, the latter followed by a narrow elongate plate, placed between the arm-bearing brachials. Interdistichal spaces deeply depressed, and the centre occupied by a small, nodose plate. Ventral disk very high, the interambulacral spaces slightly grooved toward the arm regions. Plates more or less tumid, irregular in form and size. Orals indeterminable, and possibly unrepresented. Covering pieces of first and second orders represented by single plates; the succeeding orders by two rows of small alternate pieces, which take part in the tegmen. Anal tube strong, constructed of similar plates to those of the ventral disk, but somewhat smaller. Column apparently small; axial canal large for the genus and quinquelobate.

Horizon and Locality. — Same as last.

Type in the (Worthen) Illinois State collection.

***Cactocrinus cœlatus* var. *spinotentaculus* HALL.**

Plate LIX. Fig. 10.

1860. *Actinocrinus spinotentaculus* — HALL; Suppl. Geol. Rep. Iowa, p. 86; N. Y. State Mus. Nat. Hist., Bull. I. (1872), Plate 3A, Figs. 13 to 17.

1885. *Actinocrinus spinotentaculus* — W. and SP.; Revision Palæocr., Part III., p. 112.

Agreeing with *C. cœlatus* in the number of arms, the arrangement of the plates, and their style of ornamentation; but departing from it in the form and proportions of the calyx, which expands abruptly from the distichals, and is at the arm bases almost as wide as high. *Actinocrinus spinotentaculus* is in our opinion only an extravagant form of *Cactocrinus cœlatus*, in which some of the arm joints, which in the latter are free, were incorporated into the calyx; and this, together with a slight increase in the thickness of the arms, fully explains the modifications above mentioned.

Horizon and Locality. — Same as last.

Type in the University Museum, Göttingen, Germany.

Cactocrinus fossatus S. A. MILLER.*Plate LV. Fig. 12.*

1892. *Actinocrinus fossatus* — S. A. MILLER; Adv. Sheets 18th Rep. Geol. Surv. Indiana, p. 40, Plate 6, Figs. 11 and 12.

Calyx moderately large, subovoid. Dorsal cup truncated at the base, the sides a little convex; height and width as 3 to 4. Plates rather delicate and deeply sculptured. The middle of the plates occupied by a sharp angular node, from which angular ridges, one to each side, pass out to the margins, where they meet with those of adjoining plates. Angles of the plates depressed, the suture lines rather indistinct.

Base short, projecting laterally, and forming a rim, which expands beyond the column and the lower face of the radials, and is slightly notched at the interbasal sutures. Columnar cavity rather shallow. Radials wider than long. First costals about two thirds the size of the radials, hexagonal; second costals a little larger than the first, pentagonal or hexagonal. Distichals, palmars, and post-palmars all axillary, the post-palmars supporting the free arms, of which there are eight to the ray. Ambulacral openings almost equidistant, the interspaces between those of adjoining rays a very little the widest. Interradial areas arched by the post-palmars; those of the regular sides consisting of five plates: 1, 2, 2. Anal plate as large as the radials; followed by 2, 3, and 2 smaller pieces. Ventral disk highly convex, only one fourth shorter than the cup; covered with large plates, and each of them prolonged into a heavy spine. Orals pushed to the anterior. Anal tube almost central.

Horizon and Locality. — Lower Burlington limestone; Sedalia, Mo.

Type in the collection of S. A. Miller.

Remarks. — Approaching *C. cælatus* in the form and ornamentation of the dorsal cup, and also in the number of arms; but differing in the form and construction of the ventral disk, which in the latter is higher, and gradually tapers to the anal tube, instead of being highly convex as in this species. In *C. fossatus* the disk plates are less numerous, almost of uniform size, and each one is extended into a long, heavy spine; while those of *C. cælatus* vary considerably in size, the principal ones being slightly nodose, and the others almost flat.

Cactocrinus ornatissimus W. and Sp.*Plate LVII. Fig. 3.*

1887. *Actinocrinus ornatissimus* — W. and Sp.; Geol. Rep. Illinois (1890), Vol. VIII., p. 163, Plate 16, Fig. 9 (not Plate 17, Fig. 3).

1890. *Actinocrinus ornatissimus* — S. A. MILLER; N. Amer. Geol. and Pal., p. 219.

Of medium size, specimens of light color. Dorsal cup depressed, semiglobose; height equal to half its width; plates delicate and highly ornamented, but not convex; suture lines difficult to see. The surface is marked by a system of sharply elevated, very prominent rounded ridges, passing from plate to plate, and meeting in large stellate clusters in the interbrachial spaces; those following the middle of the radial series are widest, and pass from the basi-radial suture into the arms; they increase in width toward the arm bases, and divide the surface into five well defined pentangular fields. Scattered between the ridges there are bead-like nodes, and the ridges are more or less undulating.

Basals short; forming a small rim, which is slightly notched at the sutures. Radials and costals decreasing in size in ascending order, all wider than long; the first costals quadrangular with convex sides; the second generally heptangular. Distichals and palmars one, except in the outer divisions of the rays, in which the first palmar is succeeded by two to three cuneate plates, which support an arm; while the inner ones are axillary, and followed by two post-palmars with two arms; there being normally three arms to each main division, and six to the ray. Arms long, moderately stout, rounded on the back, their tips curved and folded inward; they are composed at their bases of cuneate pieces, which interlock and gradually become biserial, every second to fourth joint of both series being long, and bearing a conspicuous, tooth-like node. The intervening joints are much shorter, and connected longitudinally by waving sutures. Pinnules closely packed and contiguous; composed of short joints, and each one armed with a short hook. Interbrachials comparatively large, occupying fully one half of the whole interbrachial space, and rising to the middle of the second costals; there are two plates in the two succeeding ranges, which are followed by the interambulacrals. First anal plate as wide as the radials, and often higher, supporting 2, 3, and 2 plates. Interdistichals generally three, with frequently a small interpalmar. Ventral disk short hemispheri-

cal, paved by small, irregular pieces, interspersed with nodose larger ones. Orals proportionally small, as also the radial dome plates. Anal tube comparatively small, and apparently short. Column composed of joints alternating in size; the internodal joints knife-like, the nodal ones rounded at their margins, and slightly crenulated. A similar crenulation occurs also at the rim of the basals, giving it the appearance of a stem joint.

Horizon and Locality.—Kinderhook group; Le Grand, Marshall Co., Iowa.

Types in the collection of Wachsmuth and Springer.

Remarks.—This species resembles *Actinocrinus tenuisculptus* in the style of ornamentation; but differs from it decidedly in the arm structure, and the form of the ventral disk, which is very much lower, and the anal tube much smaller.

Correction.—The specimen represented by figure 3 on Plate 17, Vol. VIII. of the Illinois Geological Report, which was referred to this species, represents a good example of *Cactocrinus Arnoldi*.

***Cactocrinus nodobrachiatus* W. and Sp.**

Plate LVII. Figs. 1 and 2.

1887. *Actinocrinus nodobrachiatus*—W. and Sp.; Geol. Rep. Illinois (1890), Vol. VIII., p. 165, Plate 15, Fig. 5, Plate 16, Fig. 10.

1890. *Actinocrinus nodobrachiatus*—S. A. MILLER; N. Amer. Geol. and Palæont., p. 219.

Specimens buff colored with brownish tint. Dorsal cup inverted bell-shaped, the sides moderately convex, abruptly spreading below the arm bases. Plates decidedly convex, deeply pitted at their angles, and covered with radiating ridges, which, though moderately well defined near the edges of the plates, are in the central portions either obsolete or become indistinct, even in well preserved specimens, and appear as if they had been worn off by attrition.

Basals short, expanding into a conspicuous rim with a sharp edge, which projects beyond the limits of the column; interbasal sutures deeply notched, giving to the base a tripartite outline. Radials and costals decreasing in size upwards, the former as long as wide, the latter wider than long. First costals hexangular, sometimes pentangular, or even quadrangular when not in contact at any side with the interbrachials of the second range; the second costals almost twice as wide as high. Distichals one, smaller than the costal axillaries. Palmars one, small, the two inner ones axillary and

followed by two arms, the two outer supporting one arm each, there being normally six arms to the ray, exceptionally five. Arms equidistant, crowded at their bases, and bending abruptly outward; they are very long, rounded on the back, and tapering; the tips infolded, descending to the top of the calyx. The back of the arms covered with two series of rather large nodes, whose sharp points are directed upwards. These nodes are larger than those of the preceding species, but not so regularly arranged, and are farther apart; they are not confined to one plate, but generally extend over two or more, sometimes even encroaching upon those of the opposite series. Pinnules long, constructed and arranged as in *C. ornatissimus*. Regular interbrachials five, the two of the second row almost as large as the first. Anal plate, which is generally a little narrower than the radials, supports 2, 3, and 2 plates. There is one interdistichal, but no interpalmar. Ventral disk hemispherical, covered by large spiniferous plates, separated by small, almost flat pieces. The posterior oral is erect, and forms a part of the ventral tube, which is almost central and comparatively short. Column moderately strong, composed of alternate large and small joints, rounded on their edges. In a specimen before us in which the stem is preserved to its distal end, it measures nearly 27 cm. The upper half is stouter than the lower half, which ultimately terminates in a fine point, and is for some distance provided with small branches, too delicate to have served as a means for permanent attachment.

Horizon and Locality. — Same as last.

Types in the collection of Wachsmuth and Springer.

Remarks. — Differing from the preceding species in the style of its ornamentation, the abrupt spreading of the calyx near the arm bases, its greater length, and in the large, spiniferous plates of the ventral disk.

Cactocrinus Arnoldi W. and SP.*Plate LVII. Figs. 4a, b.*

1887. *Actinocrinus Arnoldi* — W. and SP.; Geol. Rep. of Illinois (1890), p. 168, Plate 17, Fig. 10, and Fig. 3.*

1890. *Actinocrinus Arnoldi* — S. A. MILLER; N. Amer. Geol. and Palæont., p. 217.

Of medium size, with long, slender spreading arms, and fan-like fringes of pinnules. Form of calyx subovate, gibbous below, spreading at the arm bases. The surface of the plates indented with numerous shallow pits and short grooves, whose rims, which are somewhat rounded off, connect with each other from plate to plate, and on the same plate in intersecting wrinkles, all of which produces on the surface a somewhat irregular, cancellate sculpturing.

Basals short, without projecting rim; the suture lines not grooved. Radials large. First costals hexangular, half the size of the radials; the second still smaller and heptangular. Distichals and palmars small. Number of arms variable, from four to six to the ray, — six being the exception; they are heavier than in the preceding species, less crowded, and composed of a double row of very short pieces, united longitudinally by waving sutures; they are ornamented on the back in the upper portions by two rows of small nodes, one to each plate, in the lower portions by a more prominent node on every sixth or seventh plate. Pinnules long and in close contact, the proximal eight or nine joints provided with conspicuous hooks, directed upward, and forming with corresponding hooks of adjoining pinnules regular rows, parallel to the arms. Regular interbranchials six or more; the first equal in size to the first costals, the two of the second range to the second costals, the upper ones considerably smaller. The anal side consists of about eleven plates, the two upper ones resting between the arm bases, and in contact with the ambulacrals. Ventral disk depressed hemispherical, occupying less than one third the height of the calyx. It is composed of numerous very small pieces, of irregular arrangement and nearly equal size, most of them flat, with a few convex pieces scattered among them. Anal tube small, slightly excentric, abruptly rising from the ventral disk. Column composed of short joints of nearly uniform width.

Horizon and Locality. — Same as last.

* See correction under *Cactocrinus ornatissimus*.

Type in the collection of Hon. Delos Arnold, Pasadena, California; other specimens in the collection of Wachsmuth and Springer.

Remarks. — This species differs from *C. nodobrachiatus* in the smaller number, and the less spreading of the arms, as well as in the construction of the ventral disk; from *C. ornatissimus* in the form and proportions of the dorsal cup, and the ornamentation of the plates.

Cactocrinus glans HALL.

Plate LIV. Figs. 5, 6a, b, 7.

1860. *Actinocrinus glans* — HALL; Suppl. Geol. Rep. Iowa, p. 16.
 1881. *Actinocrinus glans* — W. and SP.; Revision Palæocr., Part II., p. 143.
 1893. *Actinocrinus glans* — WHITFIELD, Mem. Am. Mus. Nat. Hist. New York, Vol. I., p. 10, Plate I., Figs. 11, 12.
 Syn. *Actinocrinus tholus* HALL; 1860, Suppl. Geol. Rep. Iowa, p. 35.
 Syn. *Actinocrinus eryx* HALL; 1861, Descrip. New Pal. Crin., p. 12.
 Syn. *Actinocrinus Blairi* S. A. MILLER; 1892, Adv. Sheets Geol. Surv. Indiana, p. 35, Plate 5, Figs. 27 and 28.

A rather large species. Calyx subovate, a little longer than the width at the arm bases. Dorsal cup abruptly spreading above the distichals, its height fully twice that of the ventral disk. Plates of the dorsal cup from almost flat to nodose; the surface smooth, except that the radials occasionally show faint indications of striæ at their lower ends. Suture lines rather distinct.

Basals large, forming a cup, twice as wide as high, a little excavated at the lower end, its sides slightly spreading or convex. Radials twice as large as the costals, longer than wide, the upper sloping faces much shorter than the lateral ones. Costals as wide as long, the first hexagonal, the second heptagonal. Palmars in contact laterally, each one supporting an arm, which is free from the second plate. Arm facets large, directed obliquely upwards, and concave; the respiratory pores placed very close to the ambulacral openings, and the thin partition walls rarely intact; ambulacral openings nearly equidistant. Arms twenty, very long, moderately heavy, and rounded on the back, the tips not incurving, and the spines of the pinnules small. Regular interbranchials from eight to ten: 1, 2, 2, 2, 2, 1; gradually decreasing in size in ascending order. The anal plate in large specimens is followed by 2, 3, 4, 3 and 2 plates. Ventral disk regularly convex; composed of but few, comparatively large, and almost flat pieces, of so irregular arrangement that neither the orals nor radial dome plates can be recog-

nized. Anal tube very long and slender; composed of small, transverse, flat pieces. Column moderately thick; the nodal joints long, a little projecting, and their outer edges slightly convex; the axial canal large and sharply pentangular.

Horizon and Locality.—Upper Burlington limestone; Burlington, Iowa.

Type in the (Worthen) Illinois State Collection, Springfield.

Remarks.—This is a variable species, and the only one of the genus surviving the Lower Burlington bed. The plates of the calyx vary from scarcely convex to highly nodose; specimens having the first kind of plates were described as *Actinocrinus glans*, and those with the latter as *A. tholus*. Under *Actinocrinus eryx* Hall redescribed a third species, in which the arms and anal tube were preserved, but unfortunately, in his photographic plates of eleven years later, he confounded the specimen, which we have examined in the Museum of Comparative Zoölogy, with *Periechocrinus Whitei*, a species with branching arms, and without anal tube.

TELEIOCRINUS W. and SP.

1881. W. and SP.; Revision Palæocr., Part II., p. 146 (Proceed. Acad. Nat. Sci. Phila., p. 320).

1889. S. A. MILLER; North Amer. Geol. and Palæont., p. 286.

Syn. *Calathocrinus* HALL; 1861 (not von Meyer 1848) in part; Descr. New Palæoz. Crin., p. 12.

Syn. *Strotocrinus* (Section B) MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 190.

A modified and extravagant form of *Cactocrinus*. Calyx obconical to the base of the palmars, then spreading horizontally, and forming a broad and continuous rim around the calyx, from the outer margins of which the free arms are given off to the sides. Ventral disk short, supporting a long, nearly central anal tube. Ornamentation of the dorsal cup similar to that of *Actinocrinus* and *Cactocrinus*, but somewhat coarser, and the nodes more conspicuous than the striations, often obscuring the latter. Basals three, large, massive, more or less projecting beyond the sides of the column. Radials and costals generally as long as wide or longer, but the costals in proportion considerably smaller. Distichals 1×10 , all axillary, separating the rays into two divisions (but not into lobes), which subdivide by alternate bifurcation from every successive brachial to the last in the calyx, which bears two simple arms. The successive orders of brachials of the two divisions are very numerous; they invariably consist of a single row of plates, and in each order only the plate of one side bifurcates again; the opposite one is truncate, and is followed by a variable number of other plates of the

same order, which become free arm plates at the margin of the rim. The various series thus formed are in contact laterally, and united by suture with each other; those of adjoining rays, as well as those of the same ray, forming together the peculiar rim which surrounds the calyx at the brachial zone. The plates of the rim are of nearly the same size; they form longitudinal, angular ridges, and from the outer end of each ridge proceeds an arm. Arm openings large, all with a small respiratory pore at one side. Arms very numerous, moderately long, simple, closely crowded together, and rather small in proportion to the large size of the calyx. The pinnules, so far as observed, provided with well defined hooks. Interbrachials numerous, separated from the interambulacral plates by the higher orders of brachials, generally from the palmars up. Interdistichals one or two. Ventral disk convex, in form of a ten-rayed star, slightly plicated near the outer margins, and composed of a large number of plates, which decrease in size outward. The orals, although well defined in young specimens, can scarcely ever be identified in older ones. The inner floor of the tegmen is strengthened by braces, which increase in thickness as they recede from the centre, and on approaching the rim form tunneled passages for the reception of the ambulacra. The ambulacra follow the inner floor of the disk, being placed at a slight distance from it; they are roofed over wholly or in part by superimposed interambulacral pieces, which, together with the radial dome plates, if present, form a rigid and independent covering above the food grooves. Column covered with rows of angular processes, passing up and down its sides at equal distances, giving to the column a highly sculptured, angular appearance, especially in its upper portions, where these processes are more prominent, and in almost continuous vertical lines. They pass out from the nodal joints, but intrude upon the intervening smaller ones, and grow farther apart with the increase of internodal joints.

Distribution. — This genus, like other extravagant forms, has a very limited geological and geographical range, being restricted, so far as known, to the Burlington group of the Mississippi Valley.

Type of the genus: *Teleocrinus umbrosus* Hall.

Remarks. — We have called *Teleocrinus* "a modified and extravagant form of *Cactocrinus*": nevertheless we regard it as a good genus. It is evidently the lineal successor of that genus in the Upper Burlington limestone, having the same mode of bifurcation of the higher brachials, and other general similarities. *Cactocrinus* flourished abundantly in the Lower Burling-

ton, and, with the exception of the aberrant and doubtful *C. glans*, did not survive it. *Teleocrinus* is represented in the lower beds by a single transition form, but became established in the Upper Burlington to the extent of five species. The phylogenetic development is apparent: The arms of this group became so numerous and crowded that they were naturally pushed outward for want of room, and their bases, being in such close contact as to be immovable, became united by suture, and thus formed the rim. Other modifications took place simultaneously at the inner floor of the disk, where tubular passages were formed for the reception of the ambulacra; and the column, which in this group is comparatively small, was strengthened by longitudinal braces.

***Teleocrinus umbrosus* HALL.**

Plate LIX. Fig. 7, and Plate LX., Figs. 2a-d.

1858. *Actinocrinus umbrosus* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 590, Plate 11, Figs. 3a, b.
 1866. *Strotocrinus umbrosus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 190; and *ibid.*, Vol. V., p. 360, Plate 8, Fig. 5.
 1881. *Teleocrinus umbrosus* — W. and SP.; Revision Palæocr., Part II., p. 149.
 1889. *Teleocrinus umbrosus* — S. A. MILLER; N. A. Geol. and Palæont., p. 286.
 Syn. *Actinocrinus agilops* HALL; 1860, Suppl. Geol. Rep. Iowa, p. 5.
 Syn. *Strotocrinus agilops* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 190.
 Syn. *Teleocrinus agilops* — W. and SP.; Revision Palæocr., Part II., p. 148.
 Syn. *Teleocrinus agilops* — WHITEFIELD; 1893, Mem. Am. Mus. Nat. Hist. N. Y., p. 21, Plate 2, Figs. 27, 28.
 Syn. *Actinocrinus delicatus* M. and W.; Geol. Rep. Illinois, Vol. V., p. 343, Plate 8, Fig. 2.

A moderately large species. Calyx about as high as its width at the arm bases. Dorsal cup conical to the base of the rim, which rises from above the distichals. Ventral disk dome-shaped; its height equal to one third—or less—the height of the dorsal cup. Rim wide, almost horizontal. Plates exceedingly variable; in some specimens extremely knobby, with corrugated or uneven surfaces, in others merely convex and almost smooth; but most generally there are short ridges traversing the sutures, which enter the margins of the plates, and the middle part is nodose. The nodes of the radials are large and massive, and like those of the costals transversely elongate, while those of the interbrachials are round and conical. The plates of the rim are ridged longitudinally, and in the specimen look like crowded free arms.

Basals thick, strong, their lower margins extended outward in a thickened rim, and downward in form of nodes, two to each plate, which project

over the sides of the two or three proximal stem joints; the suture lines deeply notched, the grooves reaching to the top of the plates. Radials as long as wide, and as large as both costals together; the second costals smaller than the first. Distichals as large as the axillary costals; the succeeding brachials much smaller, giving off the arms in the usual way. Large specimens have seven bifurcations in each main division, and hence sixteen arms to the ray, smaller ones five to six, with twelve to fourteen arms. Arms of moderate length and quite delicate, their lateral margins serrated. Regular interbrachials: 1, 2, 2, 2, gradually decreasing in size upwards. Anal plate generally a little smaller than the radials, followed by 2, 4, 3 and 2 plates. Ventral disk almost flat at the margin, dome-shaped above. It is composed of large and small plates, the former nodose, the latter convex and interposed between the larger ones. Anal tube central, stout and long, rising above the tips of the arms, and constructed of rather small, convex, transversely elongate pieces. Column of less than medium size; the nodal joints long, their outer margins crenulated, being covered with numerous small, longitudinal processes, which hang down slightly over the intervening smaller joints.

Horizon and Locality.—Upper Burlington limestone, Burlington, Iowa, Quincy, Ill., and other places.

Type in the (Worthen) Illinois State collection.

Remarks.—We have examined of this species over one hundred specimens of all sizes, most of them calyces, but some with the arms attached, and find among them considerable variation in the ornamentation (compare Plate LX. Fig. 2*a* with 2*b*), as well as in the number of arm openings, without showing any other structural differences; they even agree in the peculiar and unique ornamentation of the stem. A careful comparison of these specimens has shown us no way by which a separation of them can be made upon any constant characters. We have observed that the younger specimens have fewer arms than the older ones, and that the number of arm openings increased as the rim grew larger, *i. e.*, extended out farther. We also found that the specimens in their earlier phases passed through the *Cuclocrinus* stage, where they had no rim, and in which some of the higher bifurcations took place in the free arms (Plate LX., Fig. 2*d*). Among the calyces, the smallest ones have but 4 arm openings to the ray, somewhat larger ones 6, others 8, 10, 12, or 14, while in the largest ones there are 16; showing again how little reliance, in some groups, can be placed upon the

number of arm openings or the number of arms as a specific character, unless the relative maturity of the individual is considered. The two figures on Plate LX. give the most extreme forms of this species; as a rule, the plates are neither so smooth nor so nodose as in those specimens.

Teleocrinus rudis HALL.

Plate LIX. Figs. 1, 2, 3.

1860. *Actinocrinus rudis* — HALL; Suppl. Geol. Rep. Iowa, p. 33.
 1873. *Strotocrinus rudis* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 349.
 1881. *Teleocrinus rudis*, W. and SP.; Revision Palæocr., Part II., p. 149.
 1889. *Teleocrinus rudis* — S. A. MILLER; North Amer. Geol. and Palæont., p. 286.
 Syn. *Actinocrinus clivosus* — HALL; 1861, Boston Journ. Nat. Hist., p. 274.
 Strotocrinus clivosus — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 349.
 Teleocrinus clivosus — W. and SP.; Revision Palæocr., Part II., p. 149.
 Syn. *Actinocrinus (Calathocrinus) erodus* HALL; 1861, Prelim. Descr. Palæoz. Crin., p. 12.
 Strotocrinus erodus — MEEK and WORTHEN; 1866, Geol. Rep. Illinois, Vol. II., p. 190.
 Teleocrinus erodus — W. and SP.; Revision Palæocr., Part II., p. 149.
 Syn. *Actinocrinus (Calathocrinus) insculptus* HALL; 1861, Prelim. Descr. Pal. Crin., p. 12.
 Strotocrinus insculptus — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 349.
 Teleocrinus insculptus — W. and SP.; Revision Palæocr., Part II., p. 149.

A very nodose species, about the size of the preceding. Calyx to the base of the tube a little higher than its width at the base of the free arms. Dorsal cup obconical to the bottom of the rim, and fully as high; the sides almost straight. The rim begins to expand from the top of the distichals; it is directed obliquely upward, and is less prominent than usual in this genus. Ventral disk depressed-convex, somewhat decagonal in outline. Plates of the cup massive and extremely rugose, the surface being full of wrinkles and pits, and covered with all kinds of nodes and ridges, which give it a corroded appearance. The basi-radial sutures are traversed by several ridges, which generally unite at or near the middle of the radials into a prominent node, the centre of which is depressed into a deep subcircular pit. The middle part of the other plates to the height of the distichals is abruptly elevated into a large node, which is transversely elongate upon the brachials, and rounded on the interbrachials. The plates of the rim are marked by high, angular, zigzag ridges, which follow the different ramifications of the rays.

Basals large, irregularly thickened, their lower ends produced into six angular processes, two from each plate, which pass down to the second or third stem joint; they are deeply grooved along the sutures, and project in form of a tripetalous rim over the column. Radials large, their length and width about equal. First costals less than half the size of the radials, hexagonal;

the second still smaller, being considerably shorter. The size of the distichals is but little less than that of the upper costals, but the plates of the succeeding orders are considerably smaller. There are five bifurcations in each main division of the ray, and six arms, or twelve to the ray. Arms moderately long, much larger than those of the preceding species, laterally compressed at their lower ends, and distinctly angular on the back throughout. The arm joints are transversely angular, and have a small elevation or sharp node at each end, giving to the section of the arm a trigonal outline. Pinnules provided with long hooks, similar to those of *Cactocrinus*. Interbrachials: 1, 2, 2, 2; the latter on a level with the distichals, and quite small; the first as large as the first costals, or larger. Anal plate as large as the radials, followed by 2, 3, and about 6 irregularly arranged plates above, which are roofed by the palmars. Interdistichals one. Tegmen moderately convex, slightly plicated near the outer margins, and composed of large plates scattered among smaller ones. The sutures between the plates distinctly grooved, but the surface flat, and covered with wrinkles, which give it a decidedly granular appearance. Anal tube central, long, rather large around the base, but decreasing rapidly to two thirds its largest size, and then tapering slightly to the end. The tube consists of short, very wide pieces, arranged in transverse rows, and covered with wrinkles like those of the tegmen. It is surrounded at half way to the margin of the disk by an irregular ring of ten to fifteen large, spinous plates, which sometimes bifurcate, and rise to a height of from 40 to 80 mm. It is barely possible that these plates represent the orals and radial dome plates, or the latter only, but if so their arrangement is very irregular. Column beautifully sculptured with six rows of large angular processes, longitudinally arranged, which give to the stem a distinctly hexangular outline.

Horizon and Locality. — Lower part of Upper Burlington limestone, Burlington, Iowa.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — This species is most nearly related to *Teleocrinus umbrosus* Hall, but differs in never having more than twelve arms, even in the largest specimens; besides the arms are much stronger, and angular on the back instead of flattened. It also differs in the shape of the rim, and the aspect of the ventral disk, its wrinkled surface, as well as the long spines; and it is very distinct in the sculpturing of the column.

Comparison with the types shows that *Actinocrinus clivosus*, *A. erodus*, and *A. insculptus*, all described by Hall, are synonymous with this species.

Teleocrinus althea HALL.*Plate LX. Fig. 4, and Plate LXIII. Fig. 9.*

1861. *Actinocrinus (Calathocrinus) althea* — HALL; Prelim. Descr. New Palæoz. Crin., p. 13 (figured Bull. I. N. Y. State Mus. Nat. Hist., Plate 4, Fig. 13).
1881. *Teleocrinus althea* — W. and SP.; Revision Palæocr., Part II., p. 148.

A large species, remarkable for the great length of the dorsal cup, and the relative shortness of the tegmen; the former being five times the longest. Width of the rim, as compared with the length of the calyx, as seven to eight. Sides of the dorsal cup slightly convex to the top of the distichals, then curving outward and forming a broad rim. Plates moderately convex, covered with broad elongate nodes and interrupted ridges, alternating with pits and grooves. The ridges, as a rule, are directed to the middle of the plates, but without meeting in the centre, which is occupied by a more or less corrugated or pitted elevation.

Basals large, forming a spreading cup, of which the lower margin projects but little beyond the sides of the column. Radials a little longer than broad, and more than twice as large as both costals together; the latter hexagonal and heptagonal, nearly of equal size. Distichals one third smaller than the costals, wider than long. Palmars very much shorter than the distichals, twice as wide as long. The succeeding brachials smaller in proportion, all much wider than long. There are apparently eight bifurcations up to the edge of the rim, and nine arms to each division, making eighteen to the ray, and ninety arms altogether. Structure of the arms unknown. Interbrachials generally nine, in five rows, arched over by the post-palmars. The anal side contains fourteen to fifteen plates. Ventral disk almost flat, rising very slightly; the plates without definite arrangement, slightly convex. Anal tube central, very large at the base.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy, Cambridge.

Teleocrinus liratus HALL.*Plate LX. Fig. 3.*

1861. *Actinocrinus liratus* — HALL; Suppl. Geol. Rep. Iowa, p. 1 (figured 1872, Bull. I. N. Y. State Mus. Nat. Hist., Plate 4, Fig. 3).
 1861. *Strotocrinus liratus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 190, and 1873, *ibid.*, Vol. V., p. 355, Plate 7, Figs. 2a, b, c.
 1881. *Teleocrinus liratus* — W. and SP.; Revision Palæocr., Part II., p. 149.
 Syn. *Actinocrinus subumbrosus* HALL; 1860, Suppl. Geol. Rep. Iowa, p. 3.

Larger than the two preceding species, the calyx more elongate, the tegmen higher, the anal tube much heavier, the ornamentation less rugose, and the column stronger and circular instead of angular. Calyx urn-shaped, elongate-obconical to the base of the rim. Sides of the dorsal cup expanding gradually from the basals to the top of the distichals; the rim decagonal, curving obliquely outward and upward, conspicuous but not broad. Surface of plates slightly convex, covered with well defined radiating ridges, which in parallel sets of three or four unite at the middle of the plates in small, transverse or arched, angular nodes, producing a neatly sculptured ornamentation.

Basals forming a broad and deep, gradually expanding cup, slightly thickened at the lower margins; the interbasal sutures somewhat depressed, but not actually grooved. Radials generally a little longer than wide. First costals rarely more than one third the size of the radials; the second as large as the first, and both as long as wide. Distichals slightly smaller than the costals. The branching of the two main divisions takes place from opposite sides, as usual in the genus; there being five bifurcations in each division, or twelve arms to the ray. Arms of moderate size, somewhat flattened on the back, and covered with four rows of rather faint nodes. Interdistichals generally nine: 1, 2, 2, 2, 2, at the regular sides, and about thirteen at the anal side. Anal plate as large as the radials. Interdistichals one. Ventral disk higher than in the preceding species, gently curving upward from the margin of the rim, and gradually passing into the anal tube; its outer margin distinctly plicated. It is composed of numerous irregularly arranged plates, small pieces being interposed between larger ones, but, as a rule, the plates decrease in size toward the arm bases. Orals indeterminable. Anal tube very long and large throughout; composed of similar plates to those of the disk, but they are smaller

and their surfaces corrugated. Column rounded and stout; the nodal joints with undulated edges; the axial canal moderately large and pentangular.

Horizon and Locality.—Upper Burlington limestone; Burlington, Iowa, and Quincy, Ills.

Type in the (Worthen) Illinois State collection, Springfield.

***Teleocrinus tenuiradiatus* HALL.**

Plate LIX. Figs. 5 and 6.

1861. *Actinocrinus tenuiradiatus* — HALL; Prelim. Descr. New Palæoz. Crin., p. 12.

1873. *Strotocrinus tenuiradiatus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 349.

1881. *Teleocrinus tenuiradiatus* — W. and SP.; Revision Palæocr., Part II., p. 149.

A large species, remarkable for its broad rim, the great number of arms, and the flatness of the plates. Calyx urn-shaped, its height about equal to its greatest width. Dorsal cup to the base of the rim as long as wide, or longer, the sides slightly convex. The rim rapidly spreading from the top of the distichals, its outer margin at right angles to the axis of the calyx. Arm openings directed somewhat upwards. Plates very little convex, almost flat; the suture lines distinctly grooved. The plates are covered with numerous very fine and delicate striæ passing from plate to plate; they are strongest at the sutures, where they form small pits at the intervening spaces; the plates are without nodes, and the ridges are generally less conspicuous toward the middle.

Basals large, forming a cup, which spreads more rapidly than the radials and costals, and at midway is slightly constricted; the lower margin sharply angular, and the bottom concave. Radials a little longer than wide, and more than twice as large as the costals, of which the first is hexangular, the second a little smaller, and heptangular. Distichals almost as large as the second costals. The palmars and succeeding brachials forming the rim gradually decrease in size upward, all being wider than long, and almost flat. There are from seven to eight bifurcations in each main division, or eighty to ninety arms to the species; they are very much crowded, and rounded on the back near the calyx; upper parts unknown. Regular interradians eleven to thirteen in five or six ranges, those of the upper row quite small. Anal plate somewhat narrower than the radials, succeeded by fifteen or sixteen plates. Ventral disk depressed above the rim, low-conical in the middle portions, the sides gradually passing into a large central tube. Plates of

the disk and tube quite irregular in form, size, and arrangement, almost as flat as those of the cup, and growing smaller as they approach the arms. Column apparently stout, the axial canal large and pentangular.

Horizon and Locality. — Upper Burlington limestone, Burlington, Iowa.

Type in the Museum of Comparative Zoölogy, Cambridge.

Teleocrinus adolescens W and Sp. (nov. spec.).

Plate LIX. Fig. 4.

(?) Syn. *Actinocrinus penicillus* — MEEK and WORTHEN, 1873, Geol. Rep. Illinois, Vol. V., p. 342, Plate 8, Fig. 2.

Intermediate between *Cactocrinus* and *Teleocrinus*, but nearer the latter. Calyx moderately large, the height of the dorsal cup greater than the width at the rim, the sides gradually rising to the top of the distichals, then curving abruptly outward, forming a rim, which is somewhat interrupted at the interradian spaces from the palmars up. Plates thin and slightly convex, traversed by angular, well defined ridges passing from plate to plate, and forming numerous triangles. The ridges are single, except between the basals and radials, which are united by two or three. They meet at the middle of the plates in conspicuous tubercles, which are surrounded by several small nodes, placed within the corners of the triangles.

Basals of moderate size, their ridges thickened at the lower end, and formed into angular processes, which project downward and rest against the margins of the two upper stem joints. Radials larger than both costals together, as long as wide or a little longer; the first costal hexagonal, the second generally somewhat smaller and heptagonal. Distichals as large as the costals; both axillary, giving off from the outer side of the ray an arm, which is free from above the second plate, and from the inner the second axillary. This is followed by three more axillaries, of which the two lower ones, respectively, support again an arm at one side, the upper two arms; there being five arms in each main division, and ten to the ray. The brachials forming the rim are sharply angular on the back, and separated longitudinally by deep grooves. Arms somewhat flattened, quite smooth on the outer faces, but their lateral margins slightly serrated. Regular interbrachials: 1, 2, 2, 2, 1; the upper very narrow, and sometimes touching the plates of the tegmen. Anal plate followed by 2, 3, 3, 3, and 2 plates. Interdistichal areas wide and deeply depressed, occupied by two plates, longitudi-

nally arranged. Ventral disk barely rising above the rim, and deeply grooved interradially and interdistichally, the middle part conical, passing imperceptibly into the anal tube. The tegmen is composed of a large number of very small, slightly convex pieces, which enclose a few larger, sharply nodose or subspinous plates, among which the orals and radial dome plates of a first and second order are readily recognized. Tube central, large and long, constructed of irregularly arranged, transversely nodose plates. Column slightly hexangular; the axial canal large and pentangular.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

Types in the collection of Wachsmuth and Springer.

Remarks. — This species differs from all preceding ones in having a less number of arms, and deeper interradiar sinuses at the rim, which are caused by a slight gap between the arms of adjoining rays.

The small specimen in the Museum of Comparative Zoology, described and figured by Meek and Worthen as *Actinocrinus penicillus*, represents most probably a very young stage of this species. If, however, it is an adult form, which we think doubtful, it is certainly not a *Teleocrinus*, for the branches of the rays from above the distichals take the form of free arms, although directed almost horizontally and crowded together as in that genus. We found also in our own collection two small specimens, evidently of the same species as the Cambridge one, and morphologically in the same condition. In one of them we removed the arms on one side, and exposed the tegmen and anal tube, so as to enable us to see the form of the calyx. The length of the specimens to the tips of the arms does not exceed the height of the conical part of the dorsal cup in *Teleocrinus adolescens*, which to the top of the arms must have been four times as large as those specimens. The latter have but five interbranchials at the regular sides, and about eight above the anal plate, against eight and thirteen in the larger form. The arms to the fourth or fifth plate are uniserial, the joints long, cuneate and zigzag, as usual in very young specimens. The tegmen is conical, resembling the part which in the larger specimens lies inside the rim; it is composed of comparatively few and large plates, most of them spiniferous, but there are no small plates interposed between them. Both forms have ten arms to the ray — exceptionally eight or nine — which bifurcate in the same manner. The proportions of the plates, and the surface ornamentation as well, are also quite similar. So far as can be ascertained,

there is nothing between the two forms that could not be readily explained by individual growth, except the great contrast in the size of the specimens, which on the one hand are quite large, and on the other very small, the intermediate forms being wanting. This in part has led us to propose a new name for the larger form; but the principal reason is that it is practically impossible to recognize the species, or even the genus, from Meek and Worthen's description.

STROTOCRINUS M. and W.

1866. MEEK and WORTHEN (including *Teleocrinus*); Geol. Rep. Illinois, Vol. II., p. 188, and Proc. Acad. Nat. Sci. Phila., p. 253.
 1878. ZITTEL (including *Teleocrinus* and *Physetocrinus*); Handb. d. Palæont., Vol. I., p. 370.
 1881. W. and SP.; Revision Palæocr., Part II., p. 158 (Proceed. Acad. Nat. Sci. Phila., p. 332).
 1889. S. A. MILLER; North Amer. Geol. and Palæont. p. 283.
 Syn. *Calathocrinus* HALL (Subgenus of *Actinocrinus*), 1861; (not von Meyer 1848, Bronn's Jahrbuch, p. 469).

Strotocrinus holds the same relation toward *Physetocrinus* that *Teleocrinus* does toward *Cactocrinus*; the first two being distinguished by having an anal opening within the disk, while the last two have an anal tube. In the construction of the calyx as far as the top of the distichals, all these forms differ only immaterially; but from the palmars up in *Strotocrinus*, as in *Teleocrinus*, owing to the great increase in the number of arms, the brachials were crowded outwards and formed a broad, continuous, ten-rayed rim, in which not only the lower parts of the arms, but also the lower pinules, became incorporated. The specimens are of very large size, and the number of arms enormous, the disk sometimes attaining a width of 12 cm., with as many as fifteen bifurcations in each division, or one hundred and fifty arms altogether. The arms are given off alternately from opposite sides, each order consisting of a single axillary plate, which supports at one side an arm, a brachial of a higher order at the other, and the uppermost one two arms. The arms are thin and comparatively short. Interbrachials not numerous, and never extending beyond the palmars. Disk flat or very slightly convex; composed of thousands of minute, irregular plates, which decrease in size as they approach the arms. Anal opening excentric, rarely rising above the general plane of the disk.

Distribution. — Restricted, so far as known, to the Upper Burlington limestone of the Mississippi Valley.

Type of the genus: *Strotocrinus regalis*.

Remarks.—We cannot place *Strotocrinus* and *Teleocrinus* together in the same genus, as was done by Meek and Worthen, for they evidently have a different origin, the former being developed from *Physetocrinus*, the latter from *Cactocrinus*. The modifications that took place in the two forms were in the same direction, and this accounts for the resemblance which unquestionably exists between them. A very interesting feature of this genus, which has not been observed in *Teleocrinus*, is the incorporation of the lower pinnules, the plates of which take the form and office of interbrachial and interdistichal plates.

***Strotocrinus regalis* HALL.**

Plate LXV. Figs. 1a, b, c, d.

1860. *Actinocrinus regalis* — HALL; Suppl. Geol. Rep. Iowa, p. 9.
 1866. *Strotocrinus regalis* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 190.
 1873. *Strotocrinus perumbrosus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 357, Plate 8, Fig. 4.
 1881. *Strotocrinus regalis* — W. and SP.; Revision Palæocr., Part II., p. 160.
 Syn. *Actinocrinus perumbrosus* — HALL; 1860, Suppl. Geol. Rep. Iowa, p. 7.
 Syn. *Actinocrinus speciosus* MEEK and WORTHEN; 1860, Proceed. Acad. Nat. Sci. Phila., p. 386.
 Syn. *Strotocrinus bloomfieldensis* S. A. MILLER; 1879, Journ. Cincin. Soc. Nat. Hist., Plate 15, Fig. 6.

An extremely large species, the calyx across the rim to the last bifurcation reaching sometimes a diameter of 12 cm., and a height from the foot of the basals to the base of the rim of $5\frac{1}{2}$ cm., and to the tips of the arms about 15 cm. Dorsal cup urn-shaped, the sides a little convex; the distichals bending abruptly outward, and forming the base of the rim, which slopes a little upward. Tegmen almost flat, often depressed in the middle. Plates of the cup convex, covered with strong, angular ridges, which rarely meet in the centre of the plates, but run to a place near the centre, where they leave a small central depression or bare spot; sometimes, however, the middle space is occupied by a small transverse node. The ridges are in parallel sets of from three to six; there are five to six between the radials and basals, and from two to three between the other plates. The surface of the brachials in the rim is sharply elevated into angular, longitudinal, zigzag ridges, which distinctly mark the lines of bifurcation, and leave between them broad shallow grooves, which are paved at the bottom by the plates of the fixed pinnules.

Basals very large, forming a deep cup, the sides of the plates beveled,

forming shallow grooves along the sutures, which are in many specimens indistinct or concealed from view by the large adherent upper stem joint. Radials and anal plate very large, generally longer than wide, their lateral faces much larger than the others. First costals of the same form as the radials, but a third smaller; the second a little shorter than the first. Succeeding brachials to the margin of the rim about as long as wide, gradually decreasing upward, each one supporting an arm from one side, and an axillary of higher rank from the other — except the upper one, which supports two arms — the lower arm plates and their pinnules taking part in the rim. The arms from the distichals are incorporated to the sixth plate, those from the palmars to the fifth, and so on to the last bifurcation; the arms of the former being given off toward the outer sides of the rays, those of the latter to the inner; the first pinnule of each arm proceeds from the proximal plate. There are fourteen bifurcations in each main division of the ray, with as many as fifteen arms, or thirty to the ray, and one hundred and fifty to the species. But from the eighth bifurcation upwards the arms are semi-free — only the proximal plate of each arm being attached — and thus are in a similar condition to the arms of *Steganoecrinus* (Plate LXV, Fig. 1*b*). The free arms are short, simple, and biserial. Interbrachials: 1, 2, 2, 2, 2, 1 at the four regular sides, and 2, 3, 3, 3, 2, 1 at the anal interradius; the two upper rows forming part of the rim, being arched by the plates of the fixed pinnules of adjoining rays. The interdistichals consist of only one plate, which is arched by pinnules. Ventral disk covered by many thousands of small irregular pieces, which decrease in size as they approach the arms; those occupying the middle portions almost flat, those near the outer margins slightly nodose. Anus subcentral, small, the opening directed anteriorly. Column large, round; the nodal joints but little wider than the intervening ones, their edges covered with a row of small nodes.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa, Quincy, Ills., Hannibal, Mo., etc.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — We obtained at Burlington a very large specimen of this species, which with stem and portions of the root measures about two feet in length; the width of the stem near the calyx is 8 mm.; its greatest width, about five inches from the lower end, 12 mm.; the width of the branchlets, 5 mm. From the first branchlet, which is followed in the specimen by nine or ten others of nearly the same width, it tapers gradually to 6 mm., from

which we infer the root was probably from four to five inches longer. The branchlets are irregularly arranged; they were apparently quite long, as one of them, which is preserved to the length of 3 cm., retains its full thickness to the end.

The number of arms probably varies from twenty-four to thirty to the ray. The latter number occurs in two of our largest specimens, while a smaller one in the M. C. Z., which Meek and Worthen identified as *Strotocrinus perumbrosus* Hall, has but twenty-five.

***Strotocrinus glyptus* HALL.**

Plate LX. Figs. 1a, b, c, and Plate LXV. Figs. 2a, b.

1860. *Actinocrinus glyptus* — HALL; Suppl. Geol. Rep. Iowa, p. 2.

1881. *Strotocrinus glyptus* — W. and SP.; Revision Palæocr., Part II., p. 160.

A little smaller than the preceding species, the cup comparatively shorter, and the tegmen convex instead of flat. Calyx obconical to the top of the distichals, then bending abruptly outward and forming a decangular rim at right angles to the axis of the calyx; height to width at the rim as two to three. Plates convex, covered with radiating ridges, meeting at a small node in the centre, and communicating with the ridges from adjoining plates. Toward the basals there are four ridges from each antero-lateral radial and the anal plate, and three from the anterior and two posterior radials; while there is but one between the other plates. Zigzag ridges, as in *S. regalis*, formed by an angular longitudinal elevation on the brachials in the rim, follow the lines of bifurcation, and leave angular depressions between.

Basal cup twice as wide as high, the sides almost vertical; grooved along the sutures; axial canal moderately large and pentangular. Radials as wide as long, and nearly as large as both costals together. First costals hexagonal, the second heptagonal, shorter than the first. The brachials of the succeeding orders as long as wide, slightly decreasing in size upwards, each one supporting at one side an arm, of which the lower plates are incorporated into the rim, at the other a brachial of higher rank, and each arm giving off pinnules whose proximal joints also take part in the rim. The arms proceeding from the distichals are free above the fifth plate, those of the palmars from the fourth. There are eight bifurcations in this species, giving origin to nine arms from the main branches, and eighteen from the

rays. Arms comparatively short, and rather delicate; slightly flattened at the upper ends. Regular interbranchials: 1, 2, 2, followed by 2 and 1 plate within the rim; the latter piece arched over by the plates of the proximal pinnules of the proximal arms in adjoining rays; the anal interradius consists of 2, 3, 4, 2 and 2 plates. Interdistichals one, roofed by the incorporated lower pinnules of the second arm. Tegmen rising but slightly at the top of the rim, the middle portion low dome shaped; the plates very numerous, irregularly arranged, nearly flat, gradually decreasing in size toward the arm bases. Anus subcentral, at the top of a small protuberance.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa, and at several places in Missouri.

Type in the (Worthen) Illinois State collection.

Remarks. — This species differs from the preceding one in the smaller size, the shortness of the calyx, the less number of arms, and in the convexity of the ventral disk.

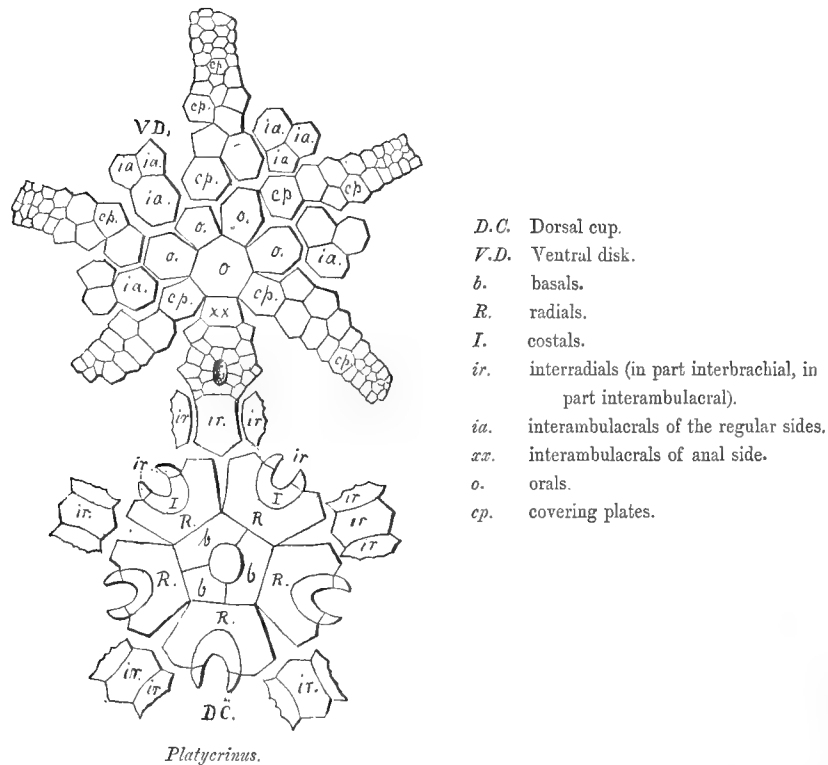
PLATYCRINIDÆ ROEMER.

MONOCYCLIC. BRACHIALS AND INTERBRACHIALS ONLY SLIGHTLY REPRESENTED IN THE DORSAL CUP; THE LOWER BRACHIALS TAKING MORE OR LESS THE FORM OF FREE ARM PLATES; THE LOWER INTERRADIALS IN PART INTERAMBULACRAL IN POSITION, RARELY ENTIRELY INTERBRACHIAL. RADIALS IN CONTACT ALL AROUND, THERE BEING NO SPECIAL ANAL PLATE. BASALS FORMING A PENTAGON.

Analysis of the Genera.

Basals 3, unequal, frequently anchylosed.

- A. COSTALS TWO.
 - 1. *Column circular.*
 - a. *Disk almost completely occupied by the orals; ambulacra subtegmina; orals separated from radials by only one ring of interradials.*
 - Orals symmetric; arms apparently delicate . . . *Coccocrinus.*
 - Orals asymmetric; arms heavy, biserial . . . *Culicocrinus.*
 - b. *Disk composed of numerous plates; orals not observed; arms uniserial, or slightly interlocking* *Cordylocrinus.*
- B. COSTALS ONE.
 - 1. *Orals occupying but a small part of the disk, and asymmetrically arranged; ambulacra exposed; arms biserial.*
 - a. *Column circular; canal large, quinquelobate; distichals one when more than one bifurcation* *Marsupiocrinus.*
 - b. *Column elliptic; canal small, round; distichals two.*
 - Arms branching by alternate bifurcation *Platycrinus.*
 - Rays extended into tubular appendages giving off the arms *Eucladocrinus.*

*Platycrinus.*

Remarks. — The Platycrinidæ are the typical family of a sub-group which is distinguished from all other families of the Camerata by having the brachials and interbrachials only slightly represented in the dorsal cup. The lower brachials, although incorporated into the calyx, belong in part to the cup and in part to the disk, and have more or less the form of free arm plates. From this we conclude that the Platycrinidæ represent phylogenetically a less developed stage of the Camerate Crinoid, in which the lower arm plates remained in an immature condition, their small size giving rise to the interposition of three plates to fill up the interradial space in the first row, instead of the usual single one. The lower interradials, therefore, are for the most part neither strictly interbrachial nor interambulacral, but may be considered as belonging to both. This is not invariably the case, however. In a remarkable undescribed species of *Platycrinus* from the Mountain limestone of England, the costal and the two distichals are connected with those of adjoining rays by five or six heavy plates, which are strictly interbrachial

in position; and a similar structure, in a less degree, is to be observed in a few American species.

The above general character of this family is shared with it by the Hexacrinidæ, which were placed in the same family by all writers on Crinoids up to 1885, when we separated them. The two groups, though more closely related to each other than to any other family, are nevertheless readily distinguished by the form of the base, depending upon the presence or absence of an anal plate within the ring of radials. The Platycrinidæ have no such anal plate, the radials being in contact at all sides. The base is therefore a pentagon, and is composed invariably of three unequal plates, the sutures between them being always directed to the right posterior, anterior, and left antero-lateral radials. The interbasal sutures are, however, very often ankylosed and invisible from the exterior. The Hexacrinidæ, on the other hand, have a large anal plate interposed between the two posterior radials, resting by its full width upon the edge of the basal cup; they consequently have a hexagonal base, which in that family consists either of two or three equal plates.

The Platycrinidæ embrace six genera, of which about one hundred and eight species have been identified:—seventy-three in America and thirty-five in Europe. Although introduced in the upper Silurian, the family was not prolific in forms until the age of the Subcarboniferous, when, especially in the Lower Burlington limestone, and in their typical genus, *Platycrinus*, they reached their climax;—abounding in number and variety, and in beauty almost surpassing the Crinoids of any other group.

The modifications which took place in the course of time among the Platycrinidæ are very slight; and in fact the young *Cordylocrinus* from the Niagara, with its uniserial, sometimes zigzag arms, which it retains during life, resembles most remarkably the immature *Platycrinus* of the Subcarboniferous. *Coccoocrinus* and *Culicoocrinus* also represent stages of the growing *Platycrinus*; both have unusually large orals, which in the former are symmetric, in the latter asymmetric, and there is but a single row of interradial plates between orals and radials. The case of *Mursupiocrinus* is somewhat different; it has small asymmetrical orals occupying the centre of the disk, numerous ambulacral and interambulacral plates, and highly developed biserial arms. The genus has all the characteristics of a mature Platycrinoid except that it has the round stem of the young *Platycrinus*, but with a large quinquelobate canal; these are in fact the only characters upon

which the two genera can be separated in the fossil state. *Eucladocrinus* is an extravagantly developed *Platycrinus*, and should perhaps be regarded as a subgenus.

Coccoocrinus was placed by Müller and Roemer among the Platycrinidæ; by Pictet, Dujardin and Hupé, Zittel, and S. A. Miller, under the Haplocrinidæ; while at the same time the latter authors refer the closely allied *Culicoocrinus* to the Platycrinidæ, which according to our classification would place the one among the Larviformia and the other among the Camerata. We do not see how this can possibly be the case; we believe that *Coccoocrinus* is a true Camerate Crinoid, which passed the Larviformia stage in early life on the introduction of perisomic plates. The genus holds a similar relation morphologically toward *Platycrinus* to that of the recent genus *Holopus* toward *Hyocrinus*, whose orals have been carried inward by increased perisome.

In Part II. of the Revision we referred the doubtful genus *Cotyledonocrinus* to the Platycrinidæ, but have since found it to be identical with *Dichocrinus*.

In descriptions of the Platycrinidæ and Hexacrinidæ we sometimes use the term "interradials" for the lowest plates between the rays, because, as already stated, they are neither exclusively interbrachial nor interambulacral, but partake of the character of both; that is, the same plate often belongs partly to the dorsal cup and partly to the tegmen.

PLATYCRINUS MILLER.

1821. *Platycrinites* — MILLER; A History of the Crinoidea, p. 74.
 1833. " (in part) — GOLDFUSS; Petrefact. Germ., Vol. I., p. 188.
 1835. " (in part) — AGASSIZ; Mem. Soc. Neuchat., Vol. I., p. 197.
 1836. *Platycrinus* — PHILLIPS; Geology of Yorkshire, Vol. II., p. 204.
 1839. *Platycrinites* (in part) — GOLDFUSS; Nov. Acta Ac. Leop., Vol. XIX., p. 343.
 1841. *Platycrinus* (in part) — JOH. MÜLLER; Monatsber. Berl. Akad., p. 207.
 1842. " — T. AUSTIN; Ann. and Mag. Nat. Hist., Vol. X., p. 109.
 1843. " — T. AUSTIN; Monogr. Rec. and Foss. Crinoids, p. 6.
 1844. " — MCCOY; Syn. Carb. Limest. Foss. Ireland (ed. 2), p. 175.
 1852. " — D'ORBIGNY; Cours élément. de Paléont., Vol. II., p. 142.
 1853. " — DEKON. and LE HON; Recherch. Crin. Belg., p. 155.
 1855. " (in part) — F. ROEMER; Lethæa Geogn. (Ausg. 3), p. 242.
 1857. " — PICTET; Traité de Paléont., Vol. IV., p. 330.
 1858. " — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 525.
 1862. " — DUJARDIN and HUPÉ; Hist. natur. des Zooph. Echin., p. 151.
 1879. " — ZITTEL; Handb. d. Palæont., Vol. I., p. 364.
 1881. " — W. and SP.; Revision Palæocr., Part II., p. 65 (Proceed. Acad. Nat. Sci. Phila., p. 239), and 1890, Proceed. Phila. Acad., pp. 351-353.
 1885. " — QUENSTEDT, Handb. der Petrefactenkunde (Ausg. 3), p. 951.
 1899. " — S. A. MILLER; N. A. Geol. and Palæont., p. 270.
 Not PHILLIPS, 1841; Palæoz. Foss. Cornwall, p. 28 = *Hexacrinus*.
 Not F. ROEMER, 1844; Rhein. Uebergangsg., p. 63 = *Coccoecrinus*.
 Not D'ORBIGNY, 1850; Prodrôme de Paléont., I., p. 103 = *Marsupiocrinus*.
 Not HALL, 1861; Palæont. N. York, Vol. III., pp. 113-117 = *Cordylocrinus* and *Marsupiocrinus*.
 Not SCHULZE, 1866; Echinod. Eifl. Kalk., p. 68 = *Storthingocrinus*.
 Not LYON, 1869; Amer. Philos. Soc., Vol. XIII., p. 459 = *Hexacrinus*.
 Syn. *Astropodia* URE, 1893, Hist. of Rutherglen.
 Syn. *Nave Encrinite* PARKINSON, 1811; Org. Rem., Vol. II.
 Syn. *Encrinites* (in part) SCHLOTHEIM, 1823; Nachtr. zur Petrefactenkunde.
 Syn. *Centrocrinus* and *Pleurocrinus* AUSTIN, 1843; Monogr. Crinoids, p. 6.
 Syn. *Edwardsocrinus* D'ORBIGNY, 1850, Prodrôme, Vol. I., p. 156.

Calyx oblong, globose or pyramidal; the dorsal cup conical, bowl-shaped, or discoid. Basals three, large; two of them equal and twice as large as the third; the latter rhomboidal and placed with its upper angle between the anterior and the left antero-lateral radials; the plates so closely anchylosed that they cannot be separated, often not leaving even a trace of the suture line. Radials very large; their upper faces partly excavated, and forming a well defined facet for the reception of the brachials; the limbs to both sides of the facets more or less sloping, forming notches which support the interradial plates. Costals one, exceptionally two,* united with the radials by an almost rigid suture, the plate being often so small as to be buried within the facets, so that the distichals touch the radials by their outer

* *P. truncatulus* from the Lower Burlington limestone, and *P. eriensis* from the Hamilton group, have two well defined costals in every ray.

margins. The distichals, and all the higher orders of brachials to the last bifurcation, generally consist of two plates each,* of which the upper one is axillary. These plates have the form of free arm plates, being rounded on the back, but the lower ones are suturally connected with the plates of the disk, and in some species also with the radials, or with their fellows of the opposite side of the ray, and are therefore rigid. The rays divide above the costals into two branches, which bifurcate independently, the axillaries of both branches bearing an arm upon one side, and the next order of brachials upon the opposite side, the last axillary supporting two arms. Pinnules strong, the first pinnule given off in some species from the first distichal, in others from the proximal arm plate.

Ventral disk pyramidal, convex, or almost flat. Orals slightly excentric, and more or less asymmetrical. Ambulacra composed of two series of covering pieces, which are exposed upon the disk. The interambulacral plates variable in number, except the first row, which in part is interbrachial, and always consists of three plates transversely arranged. The middle one of these plates is larger than the two at the sides, which are elongate and bend outward to form the ambulacral passage. The upper ends of the side plates rest against the covering-pieces of the ambulacra, the lower ends against the sides of the costals or distichals, as the case may be, and sometimes against the palmars. The anal side has also three plates in the first row, of which, as a rule, the middle one is widest and sometimes higher than the corresponding plates of the regular sides; these are followed by numerous small plates. Anus excentric, either opening out directly through the disk, or located at the top of a protuberance, sometimes at the end of a tube.

Column of moderate length, the lower end giving off rootlets at irregular intervals; the joints elliptic and twisted, the twist being imparted to the whole stem, permitting motion in all directions. The articulation between the joints bifascial, there being a well defined ridge following the long diameter of the joints. Axial canal very small.

Distribution.—This genus constitutes one of the leading fossils of the Subcarboniferous on both sides of the Atlantic. It made its appearance in the Hamilton group, and became extinct in the St. Louis, reaching its climax in the Lower Burlington limestone, from which horizon we recognize twenty-eight species, not counting the numerous synonyms.

* In *P. incomptus*, and some others, representing a transition toward *Eucladoerinus*, the orders of brachials above the palmars consist of three successive plates.

Type of the genus: Platycrinus laevis Miller.

Remarks.— We have included under *Platycrinus* species with an anal tube, as well as those in which the anus opens directly through the disk. A tube, such as was represented by the Austins, and by de Koninck and Le Hon, extending almost to the tips of the arms, has only been observed among American species in *P. excavatus*. Most of them have an excentric, mammiform protuberance with a small opening in the middle. The longest tube except the above which we have found is that of *P. burlingtonensis*; it rises but a few millimetres above the general level of the disk, and has a small opening at the end, while the end of the tube in some of the European species is closed, rounded off, and, according to Austin, valvate.

The Austins made an unsuccessful attempt to subdivide the genus upon the structure of the anus. Under *Platycrinus*, they proposed to place the species with "a central elongated oral tube." For species with a "central valvate, unobtrusive mouth, or mouth capable of being withdrawn into the visceral cup," they proposed the name "*Centrocrinus*," and "*Pleurocrinus*" for those in which the mouth is "placed laterally, or not central." Some of these ideas are altogether fanciful. The so-called "mouth," for which these authors mistook the anus, is always excentric; and a withdrawal of the anus into the body, as they imagined, is incompatible with the construction of the ventral side of Camerate Crinoids as now understood. Neither of the proposed names has been applied to any of the species, not even by the Austins; and it seems to us that, for the present at least, any general division based upon the structure of the disk and anus, is not practicable in a group in which the parts in question are but rarely observed.

In default of any other characters upon which a generic division could be established, we have arranged the species into groups, in accordance with certain specific peculiarities, hoping thereby to assist the student in the identification of the species.

Of the one hundred and twenty species of *Platycrinus* described from America, we recognize but sixty. Many are unquestionably synonyms. Others were made from such imperfect material, or so insufficiently described, that their identification is absolutely impossible. The outcome may be somewhat unsatisfactory, but it is the result of careful study and impartial consideration, and if we have erred in this respect it is probably in not carrying the process of elimination far enough. It may not be out of place to state that we devoted a long time to the revision of *Platycrinus*, and

were enabled, through the liberality of our American Museums and collectors, to make direct comparison with the types of almost every species, except some of those described by S. A. Miller, and Hall's Richfield specimens in the New York State Cabinet.

The eleven groups into which we arrange the species are based variously upon the style of ornamentation, the general form of the calyx, the details of the arm structure, and other characters, none of which can be regarded as of generic importance. Some of these groups are apparently unrepresented in Europe. None of the European species known to us are referable to the *Discoideus* group, nor to the *Subspinulosus*, *Saræ*, or *Truncatulus* groups. The European species, as a rule, are coarser in their ornamentation, the slope of the cup more abrupt, the plates heavier, the suture lines and rugosities of the plates deeper, the nodes stronger, the ventral disk higher, and often surmounted by a large anal tube, somewhat resembling that of *Actinocrinus* and *Batocrinus*. The facets upon the radials also, as a rule, are deeper, and are frequently provided with a transverse ridge, indicating that the union with the brachials was not very rigid.

We have rejected the following species as unrecognizable on account of insufficient preservation, or inadequate description.

- P. absentivus* S. A. MILLER, Chouteau group, Sedalia, Mo.
- P. amabilis* S. A. MILLER, Burlington group (?), Loc. (?).
- P. annosus* S. A. MILLER, Chouteau group, Sedalia, Mo.
- P. altidorsatus* ROWLEY and HARE, Upper Burlington limestone, Louisiana, Mo.
- P. bedfordensis* HALL and WHITE, Waverly group, Bedford, Ohio.
- P. Blairi* S. A. MILLER, Burlington group, Sedalia, Mo.
- P. calyculus* HALL, Burlington group, Burlington, Iowa.
- P. chouteauensis* S. A. MILLER, Chouteau group, Sedalia, Mo.
- P. Colletti* S. A. MILLER, Chouteau group, Sedalia, Mo.
- P. concinnus* S. A. MILLER, Burlington group, Sedalia.
- P. eboraceus* HALL, Hamilton group, Livingston Co., N. Y.
- P. Haydeni* MEEK, Subcarboniferous, Montana.
- P. marginatus* ROWL. and HARE, Upper Burlington group, Pike Co., Mo.
- P. pentagonus* S. A. MILLER, Keokuk group, Boonville, Mo.
- P. plano-basalis* ROWL. and HARE, Upper Burlington limestone, near Curryville, Mo.
- P. pumilus* HALL, Warsaw limestone, Warsaw, Ills.
- P. vezabilis* WHITE, Subcarboniferous, Nevada.

The following species we consider to be synonyms:—

- P. æternalis* S. A. MILLER = *P. bonoensis* WHITE.
- P. alabamensis* S. A. MILLER = *P. Huntsville* TROOST.
- P. batiola* S. A. MILLER = *P. æqualis* HALL.
- P. bloomfieldensis* S. A. MILLER = *P. planus* O. and SHUM.
- P. Broadheadi* S. A. MILLER = *P. americanus* O. and SH.
- P. caducus* S. A. MILLER = *P. bonoensis* WHITE.
- P. carchesium* S. A. MILLER = *P. pileiformis* HALL.

- P. clytis* HALL = *P. scobina* MEEK and W.
P. corrugatus O. and SHUM. = *P. discoideus* O. and SHUM.
P. curryvillensis ROWL. and HARE = *P. æquitermus* S. A. MILLER.
P. exsertus HALL = *P. burlingtonensis* O. and SHUM.
P. Georgei HALL = *P. Saræ* HALL.
P. richfieldensis HALL and WHITFIELD = *P. graphicus* H. and W.
P. inornatus McCH. = *P. burlingtonensis* O. and SH.
P. lautus S. A. MILLER = *P. burlingtonensis* O. and SH.
P. monroensis WORTHEN = *P. Saræ* HALL.
P. multibrachiatus M. and W. = *P. discoideus* O. and SH.
P. nodobrachiatus HALL 1861 (not 1858) = *P. Yandelli*, var. *perasper*.
P. nodosus WIRTGEN and ZEILER = *Culicocrinus nodosus*.
P. nodobrachiatus HALL 1858 (not 1861) = *P. burlingtonensis* O. and SH.
P. nodulosus HALL (not GOLDF.) = *P. ornigranulus* McCH.
P. nucleiformis HALL = *P. burlingtonensis* O. and SH.
P. olla HALL 1861 (not DEK. and LE HON 1853) = *P. Halli* SHUM.
P. Oweni M. and W. = *P. regalis* HALL.
P. parvus HALL = *Cordylocrinus plumosus* (HALL).
P. penicillus M. and W. = *P. Huntsvilleæ* TROOST.
P. plano-basalis ROWL. and HARE = *P. quinquenodus* WHITE.
P. planus HALL (not O. and SH. 1852) = *P. Halli* SHUM.
P. plenus M. and W. = *P. Huntsvilleæ* TROOST.
P. pleuroviminus WHITE = *Eucladocrinus pleurovimeus*.
P. plumosus HALL = *Cordylocrinus plumosus* (HALL).
P. præmaturus HALL = *Marsupiocrinus præmaturus*.
P. prænuntius W. and SP. = *Eucladocrinus prænuntius*.
P. prattenanus M. and W. = *P. Saræ* HALL.
P. pulchellus S. A. MILLER = *P. discoideus* O. and SH.
P. ramulosus HALL = *Cordylocrinus ramulosus*.
P. rotundus S. A. MILLER = *P. sculptus* HALL.
P. shumardianus HALL = *P. discoideus* O. and SH.
P. striobrachiatus HALL = *P. discoideus* O. and SH.
P. sulcatus S. A. MILLER = *P. excavatus* HALL.
P. tennesseensis ROEMER = *Marsupiocrinus tennesseensis*.
P. tentaculatus HALL = *Marsupiocrinus tentaculatus*.
P. truncatus HALL = *P. americanus* O. and SH.
P. tuberosus HALL = *Eucladocrinus tuberosus*.

Of the seventeen species in the above list which we have been unable to identify, the majority were described either from the basals alone, or these with the addition of the radials, and most of them from a single specimen,—a practice which cannot be too severely condemned. No palæontologist at the present day would undertake to describe an *Actinocrinus* or *Batocrinus* from a specimen showing nothing but basals and radials; and why should it be done with *Platycrinus*? There is often the greatest difficulty in defining the limits of species and varieties with an abundance of the best preserved specimens in hand. The variation of surface ornamentation in *Platycrinus* is almost without limit. The detached radials and basal plates, beautifully preserved and free from matrix, have been collected by thousands from the soft sandy layers of the Lower Burlington limestone, and it would be possible

to pick out several score of them, whose surface markings would in no two be exactly alike, and which might in sufficiently energetic hands be made into as many species. Among the smooth species of the Burlington group there are several forms, which it is absolutely impossible to separate from the shape and proportions of the dorsal cup alone. The arm structure indicates that there is more than one species, but unless the arms are attached the best Crinologist cannot identify them. Even the number of arms, upon which great stress has been laid by some authors, cannot always be depended upon unless associated with other characters. Specimens of the same species may have four to six arms in one ray, and only two or three in another. Exceptions to the general rule are nowhere more frequent than in *Platycrinus*.

All attempts at describing new species will be worse than useless if made without at least some reference to the ontogeny of the Crinoids generally, and of the particular group in hand. The modifications due to individual growth in *Platycrinus* are particularly well known, and are very striking. In the mature specimen the basal cup is proportionally deeper; the radials more elongate; the stem joints, which are circular in the young, become elliptic; the arms gradually change from uniserial to biserial, and from zig-zag to nearly straight; the arm joints are proportionally much longer in the young than in the adult; the pinnules much stouter and further apart; and the orals grow relatively smaller as they are carried inward by increasing perisome. Unless all these matters are taken into consideration, the describing of species amounts to little more than description of individual specimens. This in many cases is not without value in bringing to the knowledge of others a really new form, but when carried to excess it is the terror of the systematist who has to overhaul the work. Nevertheless, there are writers who go on describing so-called new species upon the most imperfect material, from horizons from which numerous species of the same genus have been previously described, without comparison with the types or with authentic collections of known species. The earlier authors, in the infancy of Palæontology, before the great treasures of our crinoidal faunæ had been brought to light, and without knowledge of the embryology of the Crinoids, may readily be excused for describing their species from such material as they had. But at the present day the only excuse for this class of work that can be found is the desire of the authors to see their names appended to the greatest possible number of species. A

crowning vice of the descriptions manufactured in this way, and one necessarily following the methods employed, is the frequent absence of any comparison with other forms. All we have in many cases is the assurance of the author that the species is so unlike any other that a comparison is unnecessary. We have found in practice that a declaration of this kind is a badge of suspicion, and is one of the most common indications of a synonym.

BURLINGTONENSIS GROUP.

Dorsal cup moderately deep, cup-shaped; plates rather heavy, and without ornamentation; arms long.

Platycrinus burlingtonensis O. and SHUM.

Plate LXIX. Figs. 3a, b, c, d, e, f, g, h, i.

1850. OWEN and SHUMARD; Journ. Acad. Nat. Sci. Phila. (new series), Vol. II., Part 1, and 1852, U. S. Geol. Rep. of Wis., Iowa, and Minn., p. 589, Plate 5A, Fig. 5.
 1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 452, Plate 3, Figs. 6a, b, c.
 1881. W. and Sp.; Revision, Part II., p. 70 (Acad. Nat. Sci. Phila., p. 244).
 Syn. *P. inornatus* MCCHESENEY; 1859, Description of New Species, p. 6. Figured in the Trans. Chicago Acad. Sci., Vol. I., Plate 4, Figs. 3a, b, as *P. burlingtonensis*.
 Syn. *P. exsertus* HALL, 1858; Geol. Rep. Iowa, Vol. I., Part II., p. 539.
 Syn. *P. nodobrachiatus* HALL, 1858 (not 1861); *ibid.*, p. 542.
 Syn. *P. nucleiformis* HALL, 1858; *ibid.*, p. 540.
 Syn. *P. lautus* S. A. MILLER, 1891; Geol. Surv. Missouri, Bull. 4, p. 17, Figs. 3 and 4.

Of medium size or less. Calyx a little higher than wide in the adult, width and length about equal in young specimens, the ventral disk occupying one fourth of the height. Dorsal cup bowl-shaped, slightly spreading to the arm bases; the base rounded in large specimens, more or less flattened and proportionally shorter in smaller ones. Plates moderately thick and without ornamentation; the radials toward the facets somewhat thickened or longitudinally convex, so as to give to the cup, as seen from below, a slightly pentangular outline. Basi-radial and interbasal sutures a little grooved.

Basal cup saucer-shaped, its height equal to half the length of the radials; the interbasal sutures rarely visible in the adult; the column facet circular and but little impressed. Radials about as long as wide, in large specimens somewhat longer, in smaller ones a shade shorter; wider at the top than at the bottom, the upper margins slightly incurving, and the superior angles truncated, especially at the anal side, where they form a

wide and rather deep notch. Facets occupying half the width of the plates, semi-circular, only excavated at their outer faces, the inner edges of the plates being in a straight line, which is slightly notched for the passage of the ambulacral vessels. Costals moderately large, sub-pentagonal; their lateral margins very short, directed outward and slightly upward. Distichals and palmars once and a half as wide as long, the former giving off an arm to one side, and two palmars to the other, the latter two arms, making three arms to each subdivision, or six arms to the ray. Arms rather slender, very slightly tapering, rounded on the back, their five or six proximal plates wedge-form and uniserial, the succeeding ones biserial. The arm plates are nearly as long as wide, and each one is marked by a small, transverse elevation projecting from the sides of the arms. Pinnules nearly, or quite, in contact laterally.

Ventral disk depressed hemispherical; orals large, tuberculous, eccentric, and asymmetrically arranged; disk ambulacra short and composed of few rather large pieces. The interambulacrals consist of a single row of three plates, of which the two at the sides are very narrow and bend abruptly outward; the middle one large, and resting invariably against the orals. The middle plate of the anal side, which is larger and sub-quadrangular, is followed by two medium sized plates, and these by numerous smaller ones, which together form an elongate protuberance or short anal tube, 5 to 6 mm. in length, directed upward, and curving slightly inward to the middle of the disk; its lower margin, bordering the posterior oral, slightly truncating its outer edge. Column moderately twisted, the joints decidedly elliptic in the adult, almost circular in young specimens.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa; and found at the same horizon throughout Missouri, and in Southwestern New Mexico.

Remarks. — The subglobose form of the calyx, but still more the construction of the ventral disk with its incurving anal tube and the large interambulacral plates which invariably touch the orals, distinguish this species from all others known to us.

In describing this species we had for comparison over sixty specimens of all sizes, from 12 mm., including arms, to 8 cm., showing the modifications that took place in the growing Crinoid, in the form of the calyx and the structure of the arms. The calyx of young specimens is shorter, the base more depressed, the arms zigzag, and composed of long wedge-form plates,

the pinnules proportionally large and placed wide apart. Hall described a rather young specimen, evidently of this species, as *P. nucleiformis*, another with somewhat deeper suture lines as *P. exsertus*, and one in which the arms are as yet in their embryonic state as *P. nodobrachiatus*; while S. A. Miller described as *P. lautus* a specimen showing the anal tube.

Platycrinus symmetricus W. and Sr.

Plate III. Fig. 16; Plate LXIX. Figs. 1a, b, c.

1890. W. and Sr.; Geol. Rep. Illinois, Vol. VIII., p. 186, Plate 15, Fig. 8.

Below medium size; the specimens of light color, in marked contrast to *Dichocrinus inornatus* and other species from the same locality, which are dark. Calyx nearly as wide as high, the ventral disk depressed, and occupying in adult specimens one third of the total height, a little more in the younger ones. Dorsal cup subturbinate, rising gradually from the top of the basals to the arm bases; basal cup small and short. Plates moderately heavy, almost flat except for the general curvature of the cup; the surface without ornamentation; the basi-radial and interrarial sutures distinctly channeled, the interbasal ones invisible.

Basal cup shallow, rounded; the column facet proportionally large and circular. Radials a little longer than wide, increasing in width upwards; the limbs slightly curving inward, their upper faces sloping; the middle portions of the plates somewhat projecting and thickened toward the facets; the edges rather distinctly beveled. Facets shallow and directed upwards, their width equal to one half the diameter of the radials at the upper end. Costals trigonal, small, but completely filling the facets. Distichals and palmars one fourth wider than long, and the lower plates pinnule-bearing. The upper plate of the distichals gives off an arm to the outer side and two palmars with two arms to the inner side, making six arms to the ray. The two proximal arm joints following the bifurcations cuneate and singly arranged, the succeeding ones biserial. Ventral disk low-convex, the plates very numerous and small. Orals rather symmetrically arranged, the posterior one a little larger than the others. The covering plates of the ambulacra form narrow ridges composed of two rows of small alternating pieces, which bifurcate upon the disk, and remain closed to the ends of the distichals. The interambulacral spaces are deeply depressed, and at the four regular sides of the disk consist in full grown specimens of fifteen or more pieces, of which

the middle one of the first row is subtriangular in outline, and as large as four or five of the others together. The middle plate of the anal side is somewhat smaller, and subquadrangular. It is followed by a very large number of minute pieces, which form a circular, well defined, rounded protuberance, extending from the orals to the large quadrangular plate. In young specimens (Plate III., Fig. 16), the orals are as large as in the adult (Plate LXIX., Fig. 1c); they are even more regularly arranged, and stand out conspicuously over the surrounding part of the disk; the ambulacra are shorter, and the interambulacral spaces consist of only five or six pieces, of which the middle one bears a central node. Column decidedly elliptic, except the proximal joints which are circular, and it has a rapid twist. The length of the stem, as observed in several specimens, does not exceed 15 cm.; its terminal part, after giving off a few short lateral cirri, ends in a sharp point.

Horizon and Locality.—Kinderhook group; Le Grand, Marshall Co., Iowa.

Types in the collection of Wachsmuth and Springer.

Remarks.—This species differs from *P. Agassizi* of the same horizon, in the more spreading calyx, heavier plates, grooved suture lines, and the short and rounded basal cup without projecting rim.

***Platycrinus pileiformis* HALL.**

Plate LXIX. Fig. 5, and Plate LXX. Figs. 13a, b.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 529, Plate 8, Figs. 4a, b, c.

1881. W. and SP.; Revision, Part II., p. 74 (Proceed. Acad. Nat. Sci. Phila. p. 248).

Syn. *P. carchesium* S. A. MILLER; Geol. Surv. of Missouri, Bull. 4, p. 23, Plate 4, Figs. 6, 7.

Of medium size. Dorsal cup deep, about as high as wide, somewhat expanding upwards, rounded at the base. Plates rather thin, except the radials below the facets; surface smooth.

Basal cup basin-shaped, evenly rounded, its height fully half the length of the radials, the middle portions slightly excavated for the column facet, which is circular; interbasal sutures rarely visible. Radials a little longer than wide, the sides almost parallel, the upper faces deeply notched, the notch of the anal side considerably wider and much deeper, giving to the posterior radials an asymmetrical form. Facets semi-circular, less than half the width of the plates, their upper margins but slightly excavated. Costals triangular in outline, generally occupying the full width of the facets, those of the same ray in sutural contact laterally, fully twice as wide as long, and giving off two arms each. Arms four to the ray, very heavy, subcylindrical,

tapering only near the tips; the two lower arm plates suturally connected and quadrangular; the five or six succeeding ones wedge-form and uniserial, those beyond interlocking, and gradually turning into two series of transverse pieces with parallel upper and lower faces. Pinnules heavy, knife-like, the joints long and thickened at the ends. Ventral disk half the height of the dorsal cup, flattened at the summit, the sides steep, almost in a vertical line with the radials. The interambulacral spaces at the four regular sides generally consist of six pieces, arranged in two rows; the middle one of the lower row large, the two at the sides very little curving, the three upper ones small. The interambulacra of the anal side considerably wider, the middle plate of the first row shorter and descending to a lower level than the corresponding plates of the other sides, its lower faces making a right angle; the plates above numerous, forming a small protuberance, which opens out laterally, and is separated from the orals by several moderately large plates.

Horizon and Locality.—Lower Burlington limestone, Burlington, Iowa, and Hannibal and Sedalia, Mo.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks.—This species resembles *P. burlingtonensis*, but differs in the more elongate form of the calyx; it has no such anal tube as that species, its anus consisting of a simple opening directly through the disk.

Miller's *P. carchesium*, as described from the basals and radials only, cannot be separated from *P. pileiformis*.

Platycrinus corbuliformis ROWLEY and HARE.

Plate LXXI. Figs. 11a, b.

1891. Kansas City Scientist, p. 113, Plate 3, Figs. 1 and 2.

Of the type of *P. burlingtonensis*, but the plates heavier and more spreading. Described from specimens in which only the basals, radials and a few of the interradial plates are preserved. Dorsal cup basin-shaped, rather rapidly spreading, and distinctly quinquelobate at the upper end; the plates convex and perfectly smooth; interbasal, basi-radial and interradial suture lines rather deeply depressed.

Basals forming a shallow cup, with a deep circular depression at the lower face for the reception of the column, which occupies about one third the diameter of the cup; the lower margins a little bulging, and curving

gently upward to meet the radials. Radials as wide as long, one fourth wider near the top than at the bottom; facets very large, occupying more than a third the width of the plates, and reaching down to almost one half their length; they are directed obliquely upwards, subcircular, and but slightly notched at the upper end; the surface concave, and perfectly smooth. The limbs of the radials bend a little inward, their upper faces abruptly truncated; they support three rather small interrarial plates, of which the outer ones face the costals, and are in part interambulacral.

Horizon and Locality.—Base of the Lower Burlington limestone; Burlington, Iowa.

Types in the collection of Mr. R. R. Rowley of Louisiana, Mo.

Platycrinus æquitermus S. A. MILLER.

Plate LXXI. Fig. 12.

1891. S. A. MILLER; Bull. 4, Geol. Surv. Missouri, p. 14, Plate 1, Fig. 13.

Syn. *Platycrinus curryvillensis* ROWLEY and HARE, 1891; Kansas City Scientist, p. 98, Plate 2, Fig. 5.

A moderately small species of the type of *P. pileiformis* Hall; described from the basals and radials only. Dorsal cup to the top of the radials obconical, as wide as high, truncated below, the sides very little convex; cross-section somewhat quinquelobate. Plates flat and without ornamentation; suture lines not grooved and rather obscure.

Basals closely anchylosed, forming a truncated, rapidly expanding basin, equal in height to half the length of the radials; the lower face sufficiently depressed to contain the proximal stem joint, which is circular and slightly serrated around the edge. Radials longer than wide, gradually expanding, convex longitudinally, the convexity increasing toward the facets; the sloping upper faces toward the anal side deeper, and forming a broader notch; the facets of the two posterior radials pushed to one side. Facets semi-ovoid, slightly concave, the upper edge a little excavated; they occupy half the width of the plates, and nearly one third their length, project abruptly outward, and face laterally.

Horizon and Locality.—Chouteau limestone; Sedalia, Mo.

Type in the collection of Mr. F. A. Sampson, Sedalia.

Platycrinus insolens ROWLEY and HARE.*Plate LXXI. Fig. 15.*

1891. Kansas City Scientist, p. 98, Plate 2, Fig. 4.

Type of *P. burlingtonensis*; described from the basals and radials. These plates form a moderately small, spreading cup, with very slightly convex, nearly straight sides, and broadly truncated base; cross-section near the upper end obscurely pentangular. Plates rather strong.

Base saucer-shaped; upper face produced into sharp angles; lower face perfectly flat, spreading outward into a short, well defined rim, fully twice as wide as the column, and somewhat fluted at the margin; column facet round. Interbasal sutures invisible; basi-radial and interrarial sutures slightly depressed. Radials about one fifth wider at the top than at the bottom, their length equal to their greatest width; longitudinally convex, a little contracted at the upper end; the faces supporting the interrarial pieces almost horizontal, and but slightly truncated at the anal side. Articular facets occupying one third the width of the plates; directed obliquely upward, their surfaces being covered with fine radiating striæ and an obscure transverse ridge, but without perforation.

Horizon and Locality. — Chouteau limestone; near Curryville, Mo.

Types in the collection of Mr. Rowley.

Remarks. — This species resembles *P. æquitermus* Miller; but the latter has a more concave base, the facets of the radials are more projecting and directed almost horizontally. It also approaches *P. Brittsi*, but the radial facets are much wider and larger generally.

Platycrinus Britsi S. A. MILLER.*Plate LXXI. Fig. 10.*

1891. S. A. MILLER; Bull. No. 4, Geol. Surv. Missouri, p. 23, Plate 3, Figs. 3 and 4.

Comparable with *P. æquitermus* Miller, and *P. insolens* Rowley and Hare. Of medium size. Calyx to the top of the radials cup-shaped, wider than high, broadly truncated at the bottom, the sides convex, more rapidly expanding at the basals than at the radials. Plates thick,

their surface smooth; basi-radial and interrarial suture lines distinct, but not grooved.

Basals forming a low basin, with a short rim extending outward from the lower end; the bottom slightly excavated for the reception of the stem; the plates closely anchylosed, and interbasal sutures invisible. Column facet large, circular, the extreme outer margin striated; axial canal very small. Radials as wide as long, a fifth wider near the top than at the bottom, thickened around the facets; the sides supporting the interradians very short. Facets unusually wide, occupying three fourths the width of the plates, directed obliquely upwards, a little concave, and provided with a low transverse ridge. The costals occupy the whole width of the facet, are extremely short, and very slightly angular; their sloping faces with a transverse ridge and a shallow fossa to the outer side of it. Structure of all other parts unknown.

Horizon and Locality. — Chouteau group, at Pin Hook bridge, Mo.

Type in the collection of Mr. Sampson.

Platycrinus pisum ROWLEY and HARE.

Plate LXXI. Figs. 13a, b.

1891. Kansas City Scientist, p. 113, Plate 3, Fig. 3.

A very small species. Calyx spherical, about as wide as high, the dorsal cup a little higher than the tegmen, the sides almost at right angles to the truncated base. Plates finely granular, the sutures moderately grooved, except those between the basals, which are invisible.

Base disk-like, flat, only the edges curving upwards; the place of attachment for the column circular, elevated slightly above the plane of the base; its extreme outer margin striated. Radials a little wider than long, the sides parallel; facets occupying half the width of the plates, and nearly a third of their length, semicircular, having no notch at the upper edge. Interradial plates somewhat depressed and directed obliquely upwards, except at the anal side, where they are erect and form the base of a rather prominent anal protuberance, composed of minute plates. The orals are large and convex; they rest upon the first row of interradians and against a large radial dome plate, there being no covering plates in the calyx. Structure of arms unknown.

Horizon and Locality. — Base of Lower Burlington limestone; Louisiana, Mo.

Type in the collection of Mr. Rowley.

Remarks. — From the small size of the specimen, and the structure of the ventral disk, we are inclined to believe that it represents a very young form of *P. burlingtonensis*.

Platycrinus quinquenodus WHITE.

Plate LXXI. Figs. 14a, b, c.

1862. WHITE; Proceed. Boston Society Nat. Hist., p. 18.

1881. W. and SP.; Revision, Part II., p. 74 (Proceed. Acad. Nat. Sci. Phila., p. 248).

Syn. *P. planobasalis* ROWLEY and HARE, 1891; Kansas City Scientist, p. 97, Plate 2, Fig. 1.

Of moderate size. Calyx rather rapidly and evenly spreading from the truncated base to half the height of the ventral disk; the lower brachials directed almost horizontally. Ventral disk as high as the cup, distinctly convex, extended outward to the top of the distichals, and forming well defined lobes, which give to the calyx a sharply quinquelobate outline. Plates of the dorsal cup heavy and without ornamentation, except that the base is marked by five rounded nodes, interradially disposed and directed downward. Basi-radial and interradiial sutures channeled.

Basal cup deep, fully two thirds the length of the radials, truncated at the bottom, the sides gradually spreading. Radials as long as wide, wider above than below, the median portions below the facets much the thickest; the lower faces almost straight, the upper angles deeply truncated and forming with the corresponding sides of adjoining plates deep notches; the notch of the anal side considerably deeper, extending down to fully one third the length of the plates. Facets semicircular, facing almost horizontally, the upper end not notched, or only a very little. Costals pentangular, the upper faces concave. Distichals nearly twice as wide as long, those of the same ray in sutural contact laterally, the upper ones axillary. Structure of arms unknown. Plates of the disk nodose, except the interambulacrals of the anal side, which are barely convex. Orals very large, almost symmetrically arranged; the posterior one a little larger and wedged in between the others. The plates of the disk ambulacra large and tuberculous, extending out to the ends of the distichals and forming rigid tubular extensions. Interambulacrals three, the middle one twice as long as the two at the sides, but without touching the orals. The middle plate of the anal side considerably

smaller than the corresponding plates of the other sides, and placed at a higher level than the middle one. The plates surrounding the anal opening not projecting; the opening low down, and directed laterally.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks. — This species differs from all others of this group in the abrupt spreading of the lower brachials, and the quinquelobate outline of the calyx. The nodes upon the basals, although quite distinct in the type, are in other specimens but faintly represented, and sometimes absent altogether.

Platycrinus Halli SHUM.

Plate LXXII. Figs. 6a, b, and 7a, b.

1865. SHUMARD; Catal. Palæoz. Foss. North Amer., p. 388 (Trans. Acad. Sci., St. Louis, Vol. II.).

1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 454, Plate 3, Figs. 3a, b, c, d.

Syn. *P. planus* HALL (not O. and SHUM.); Geol. Rep. Iowa, Vol. I., Part II., Plate 8, Figs. 6a, b.

Syn. *P. olia* HALL, 1861 (not DE KONINCK and LEHON 1853); Descr. New Spec. Crin., p. 16.

A rather large species; the calyx large in proportion to the length of the arms, one fifth higher than wide; height of the ventral disk, as compared with that of the dorsal cup, as two to three, the former hemispherical, the latter bell-shaped, widest around the facets. Plates of the dorsal cup slightly convex, thickened below the facets, and rather heavy throughout; inter-radial sutures somewhat depressed, giving to the cup a slightly pentangular outline.

Height of base equal to half the length of the radials, the outer surface regularly rounded, except beneath the column, which rests within a circular depression; sutures between the plates often visible. Radials a little longer than wide, slightly spreading, somewhat irregular in form, especially the posterior ones, which are frequently wider than the others and asymmetrical, owing to the wider and deeper truncation of the upper angles at the anal side. Facets rather wide and deep, semicircular to semiovoid, the upper edges slightly notched. Costals irregularly pentagonal with concave upper faces; rarely trigonal. Distichals, palmars and post-palmars from once and a half to twice as wide as long; the distichals of the same ray in sutural contact laterally, but among the palmars and post-palmars only the plates of the same subdivisions. Arms seven to eight to the ray, quite short and moderately heavy, their two or three proximal plates cuneate and alternately arranged, the succeeding ones arranged biserially; the latter rather long,

their upper and lower faces parallel, the outer lateral faces provided with a sharp projection placed in front of the pinnules.

Ventral disk convex, gradually curving to the summit, quinquelobate as seen from above, the plates slightly convex. Orals rather asymmetrically arranged; the posterior one larger than the other four, and pushed in between them. Ambulacral plates of the first order consisting of but few large pieces of rather irregular arrangement, those of the second order about one half smaller. Interambulacral plates of the regular sides five in two rows; the middle one of the first row large, elongate, hexangular, much narrower at the top than at the bottom, and deeply wedged in between the radials; the two at the sides very narrow, the edges toward the ambulacra deeply scalloped by adjoining covering-pieces. Anal side considerably larger, the notch between the radials deeper; the middle plate much shorter, wider and pentangular, supporting upon its sloping upper faces two smaller pieces, which, being at a higher level, form with their lower faces and with the sloping lower sides of the middle plate a sharp angle; the plates of the first row are followed by numerous smaller ones, which form a large rounded protuberance, containing the anus. Column moderately large; the three upper joints circular, the lower ones distinctly elliptic.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Remarks. — This species resembles *P. pileiformis* in the form of the calyx; but the plates are heavier, the arms comparatively shorter, not so heavy, and much more numerous.

***Platycrinus acclivus* S. A. MILLER.**

1891. S. A. MILLER; Geol. Surv. Missouri, Bull. 4, p. 12, Plate 1, Figs. 9 and 10.

According to Miller, the dorsal cup somewhat obconoidal, nearly one half higher than wide, slightly "angular in the direction of the arms," sutures distinct but not beveled, surface apparently smooth, but the specimen may not have preserved the surface ornamentation. Basals form an obconic, sub-pentagonal cup, a little wider than high, and truncated below. Radials a little longer than wide, very slightly expanding above, and terminating in an upward, central prolongation for the reception of the costals. Facets facing upward; less than one third the width of the plates, subcircular in outline, with the exception of a slight truncation at the inner side, and a small concave ambulacral furrow. Column round at the proximal end, "the

plates radiately furrowed near the outer margin." Miller says: "This species need not be mistaken for any other, because in *P. plumus*, and others having any resemblance to it, the angularity of the cup follows the radial sutures, and there are deep excavations for the insertion of the second radials (costals)."

Horizon and Locality. — Upper Burlington limestone; Sedalia, Mo.

Type in the collection of S. A. Miller, Cincinnati.

Remarks. — We do not quite understand what Miller means by "radial sutures;" whether he alludes to the *interbasal* sutures which are radially disposed, or to the *inter-radial* sutures. The species was described by Miller from an imperfect specimen in which, as shown by the figure, only the basals and portions of the radials were preserved, and it is possibly identical with some other Burlington species. Our description is made after Miller, we having no specimens for comparison.

***Platycrinus incomptus* WHITE.**

Plate LXXI. Figs. 1, 2, 3; Plate LXVII. Fig. 6.

1862. WHITE; Boston Journ. Nat. Hist., Vol. VII., p. 503.

1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 459, Plate 3, Fig. 7.

1881. W. and SP.; Revision, Part II., p. 72 (Proceed. Acad. Nat. Sci. Phila., p. 246).

Almost as large as *P. Halli*, and in the form of the calyx often closely resembling it, but differing essentially in the branching of the arms. Height of dorsal cup compared with the width as four to five in large specimens, and as three to four in small ones, the base of the latter being proportionally shorter, and rather distinctly flattened; the sides somewhat convex. Plates moderately heavy, the surface smooth or indistinctly granular, their edges slightly beveled, and the basi-radial and interrarial suture lines depressed or broadly channeled.

Basals more or less truncated at the bottom; the intervening sutures frequently visible in young specimens. Radials about as long as wide, the height rarely exceeding the width, a little wider near the top than at the bottom; the median portions of the plates much heavier than their margins; the upper faces on either side of the facets sloping and forming a notch, of which the one at the anal side is wider and deeper than the others. Facets semi-circular to semi-ovoid, facing obliquely upwards, very little excavated, their upper edges straight; the ambulacral notch, if represented at all, very small. Costals pentagonal or trigonal in the same specimen. When

trigonal, the outer end of the first distichal barely touches the radials. Distichals placed obliquely, about as long as half their width, the axillary obtusely angular above. There are from six to nine higher orders of brachials above the costals, of which the proximal ones consist of two pieces each, the succeeding ones of three each, all giving off from their axillaries at one side an arm, and from the opposite side the next order of brachials. The plates of the different orders decrease in width upward, but not in length, those of the higher orders being almost as long as wide, while those of the lower orders in large specimens are almost twice as wide as long. In young specimens all the brachials are proportionally longer, and the bifurcations extend to nearly the full length of the rays; while in the adult they rise to only half way up. Arms biserial from the second plate after the axillary, short for the size of the calyx, and all rise to the same height. They are composed of moderately long joints, and each one has a well defined lateral projection for the support of a pinnule.

Form of the ventral disk unknown; we observed, however, from a crushed specimen that it is composed of convex pieces apparently of a similar arrangement to that of *P. Halli*, except that the ambulacral pieces are more projecting and comparatively smaller. The large interambulacral plate of the first row at the anal side is somewhat bulging outward, and wider than long. Column elliptic and twisted, the long diameter of the joints being at 25 cm. from the calyx twice as long as the short one. The joints increase gradually downward to three times the length of those at the top, and near the base of the stem give off from their sharp ends two rows of small cirri, which follow the twist.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks. — In the branching of the arms this species approaches the genus *Eucladoerinus*, but while in the latter the successive orders of brachials form tubular appendages of the calyx closed from all sides, in *P. incomptus* they retain the characteristics of arm plates, being provided with open furrows. The type specimen shows the bifurcations only to the third axillaries above the costals, and it was supposed the species had but four arms to each side of the ray; while in fact it has from seven to ten, or as many as twenty arms to the full ray in some specimens.

Platycrinus lodensis HALL and WHITE.*Plate LXXI. Fig. 6.*

1875. HALL and WHITEFIELD; Geol. Rep. Ohio, Vol. II., Part II., p. 168, Plate 11, Fig. 3.
1881. W. and S.F.; Revision, Part II., p. 72 (Proceed. Acad. Nat. Sci. Phila., p. 246).

Of medium size. Dorsal cup deeply cup-shaped, the sides almost parallel; the plates thin and without ornamentation; the suture lines not grooved.

Basals placed almost horizontally, forming a very shallow, saucer-shaped pentangular disk, with a slightly projecting column facet. Radials rather large, their height equal to the width or slightly exceeding it; their sides almost parallel, thickened toward the facets, the upper faces a little sloping at the ends, and forming a small notch. Radial facets deeply excavated to fully two thirds the width of the plates. Costals trigonal, the lower face distinctly convex. Distichals two; the first resting completely within the facet, once and a half as wide as long; the second a little wider, and free at the outer side, but suturally connected with its fellow of the same ray; the upper angle obtuse, supporting two arms, making four to the ray. Arms proportionally long and heavy throughout their full length, rounded on the back and sides. They are composed from the second or third plate up of a double series of short, transverse pieces. Structure of ventral disk unknown. Columnar joints very slightly elliptic.

Horizon and Locality.—Cuyahoga shales, Waverly group, at Lodi, Medina Co., and at Royalton, Ohio.

Type at Columbia College, New York.

Remarks.—The form and size of the distichals are not correctly represented in Hall and Whitfield's figure, and were changed in our figure from a specimen in our collection.

Platycrinus contritus HALL and WHITE.*Plate LXXI. Fig. 8.*

1863. HALL and WHITFIELD; 17th Rep. N. Y. State Cab. Nat. Hist., p. 54; and 1875, Geol. Surv. of Ohio, Vol. I., Part II., p. 166, Plate 11, Fig. 4.

This species we only know from the description and figure. Dorsal cup broad, short, concave at the base for the reception of a large column. Plates without ornamentation. Base one third the length of the dorsal cup, forming a sharp angle at the lower edge, and slightly projecting outward. Radials wider than high, somewhat spreading. Costals subpentangular, with short lateral faces. The distichals longer than the costals. Arms four to five to the ray, short, strong, and biserial.* All other parts unknown.

Horizon and Locality.—Shales of the Waverly group at Richfield, Summit Co., Ohio.

Type in the New York State Cabinet at Albany.

Platycrinus ollicula S. A. MILLER.†

1891. S. A. MILLER; Geol. Rep. Missouri, Bull. 4, p. 19, Plate 2, Figs. 7, 8.

From medium size to larger. Dorsal cup tub-shaped, having a wide, flat bottom, slightly constricted at the top of the basals, whence it expands very gradually upwards. Plates thick and convex; sutures beveled; surface finely granular. Basals stretched out horizontally, forming a disk of which the edges project beyond the lower ends of the radials in the form of a rim, the latter being the only part of the base seen in a side view. Radials a little longer than wide, slightly spreading, their greatest convexity below the facets, the lower face forming a straight line, the upper faces not notched at all, or very little. Facets shallow but wide, occupying more than two thirds the width of the plates, and facing upwards. All other parts unknown.

Horizon and Locality.—Chouteau group, at Pin Hook bridge, and at Leucke's quarry, near Sadalia, Mo.

Type in the collection of Mr. Sampson.

* The description says four arms in the three anterior rays, and five in the two posterior ones; but if the position of the small basal is correctly figured, the five arms do not occur in the posterior, but in the anterior rays.

† We are unable to give a figure of this species, and the description is made after Miller's.

PLANUS GROUP.

Calyx elongate; the plates thin and without ornamentation; upper faces of the radials straight, or very little sloping toward the angles.

Platycrinus planus O. and SH.*Plate LXIX. Figs. 2a, b, c, d.*

1850. OWEN and SHUMARD; Journ. Acad. Nat. Sci. Phila. (new series), Vol. II., Parts I. and II., p. 57; also U. S. Geol. Surv. Minn., Iowa, and Wisc., p. 587, Plate 5A, Fig. 4a (not 4b = *P. Pratteni*).
1881. W. and SP.; Revision, Part II., p. 74 (Proceed. Acad. Nat. Sci. Phila., p. 248). (not *P. planus* HALL, Geol. Rep. Iowa, Vol. I., Part II., Plate 8, Figs. 6a, b = *P. Halli*; nor *P. planus*, MEEK and WORTHEN, Geol. Rep. Illinois, Vol. III., Plate 16, Fig. 6 = *P. Pratteni*).
- Syn. *Platycrinus bloomfieldensis* S. A. MILLER, 1879; Journ. Cincin. Soc. Nat. Hist., Vol. II., Plate 15, Fig. 4.

A moderately large species. Calyx elongate. Dorsal cup goblet-shaped, higher than wide in large specimens, height and width about equal in smaller ones; basal cup deep, obconical, slightly truncate at the bottom; radials a very little spreading to the facets, the latter projecting so as to give to the cup, as seen from above, a slightly pentagonal outline. Plates thin and perfectly smooth; the suture lines rather indistinct.

Basal cup large, obconical, its height equal to two fifths the height of the dorsal cup; the lower face slightly truncated but not excavated, obscurely elliptic, and covered completely by the column. Radials longer than wide, the sides almost parallel; the limbs somewhat inflected and knife-like at their superior edges, where they form almost a straight line with those of adjoining plates; the median portions of the plates slightly thickened, thinning out gradually toward the sutures. Width of the facets one third the diameter of the plates; horse-shoe-shaped, deeply excavated, and facing upwards. Costals short, trigonal, occupying the whole width of the facets, their sloping upper faces concave. Distichals twice as wide as long, and as long as the costals; the lower ones of the same ray in sutural contact. Palmars and post-palmars three fourths as long as wide, their lower plates connected by suture. Arms four to each subdivision; or eight to the ray; very long, rounded on the back, and but very slightly decreasing in width. The arm joints moderately short, the intervening suture lines distinctly waving. Pinnules long and in close contact laterally. The ventral disk, so far as observed from the fragments preserved, extends up almost vertically

to near the top of the first row of interradial pieces, which curve abruptly inward, so as to form with the other plates a flat surface at the top. The summit plates slightly convex. Anus excentric.

Horizon and Locality.—Lower Burlington limestone; Burlington, Iowa, and at the same horizon in Hannibal and Sedalia, Mo.

Remarks.—This species may be readily recognized by its extremely thin plates, conical base, narrow and deep horse-shoe-shaped facets, long, slender arms, eight to the ray, and the waving suture lines between the arm plates.

We regard *P. elegans*, described by Hall in the Boston "Journal of Natural History," as a young *Platycrinus planus*; the type has uniserial arms, and a round stem, which clearly shows that it is an immature specimen. The figure which Hall gives of it in Bull. 4 of the N. Y. State Cabinet is crushed and somewhat misleading with regard to the form of the dorsal cup, which is not turbinate as described, but the sides are almost parallel along the radials, and spread upwards but little, if any. We figure on Plate LXIX, Fig. 2*d*, a similar specimen, but somewhat more mature, which already has interlocking plates in the upper half of the arms, while in the lower part the arms are zigzag, and their joints long and uniserial. The joints of the young stem are remarkably long and circular, resembling those of a young *Comatula* in the *Pentacrinus* stage, being at 3 cm. from the calyx almost as long as wide, and there are no internodal joints interposed between them. Another specimen in our collection, which in all other respects agrees with the preceding one, has uniserial arms throughout like Hall's *P. elegans*.

***Platycrinus Agassizi* W. and Sp. (nov. spec.).**

Plate LXIX. Fig. 4.

Syn. *P. planus* (?) W. and Sp. (not OWEN and SHUM.); Geol. Rep. Illinois, Vol. VIII., p. 188, Plate 16, Fig. 8.

Smaller than *P. planus*. Dorsal cup elongate, the sides along the radials almost cylindrical, very slightly expanding at the middle, its lower margin produced into a sharply edged projecting rim, which in form resembles an upper stem joint, but is larger and tripartite. Plates very thin, without ornamentation, and the suture lines without grooves.

Basals forming a shallow basin, in height from one fourth to one third the length of the dorsal cup. Radials quadrangular, a little longer than wide; the plates somewhat thickened longitudinally, giving to the facets some promi-

nence; their upper angles not truncated, or very slightly, and the superior faces of adjoining limbs forming almost a straight line. Radial facets rather shallow, facing upwards. Costals short, occupying the full width of the facets, subtrigonal, the upper angle obtuse. Distichals and palmars as long as the costals, and fully once and a half as wide as long; the lower plates of the same ray sutureally connected. Arms six to the ray, exceptionally two or four in one of the subdivisions; they are long, cylindrical, and but slightly tapering. Arm plates placed obliquely, sloping to the sides, the lines of union somewhat waving. Pinnules closely packed. The structure of the ventral disk has not been observed, being almost completely covered by the arms in our specimens; only portions of the middle plate of the first interradial row are visible, which at the four regular sides are marked by a conspicuous, sharply triangular convexity, while at the anal side the convexity is quadrangular, and the plate itself bulges outward, indicating the presence of some sort of protrusion in connection with the anus. Stem distinctly elliptic, the two upper joints circular, and smaller than the diameter of the basal rim.

Horizon and Locality. — Kinderhook group; Le Grand, Marshall Co., Iowa.

Types in the collection of Wachsmuth and Springer.

Remarks. — This form was referred by us in 1890 with considerable doubt to *P. planus* O. and Sh. More perfect specimens since obtained show that it differs from that species more distinctly than we had supposed, and in redescribing it as a new species we name it in memory of Professor Louis Agassiz. *P. planus* is a larger species than *P. Agassizi*, the base is conical in place of rounded, and it has no such rim at the lower end. This rim, which is represented in every specimen, is so conspicuous, and resembles so closely a stem joint, that we were at first inclined to regard it as such, but on grinding its surface we discovered plainly the interbasal suture lines. *P. planus* also has a greater number of arms, the arm joints are longer and about horizontal, while in *P. Agassizi* they slope at quite an angle outward. It differs from *P. Pratteni* in the much smaller size of the calyx, and in having proportionally much longer arms.

Platycrinus Pratteni WORTHEN.*Plate LXX. Figs. 11, 12.*

1860. WORTHEN; Trans. Acad. Sci. St. Louis, Vol. I., p. 569.

1881. W. and Sr.; Revision, Part II., p. 74 (Proceed. Acad. Nat. Sci. Phila., p. 248).

Syn. *P. planus* (in part) — OWEN and SHUMARD; U. S. Geol. Rep. of Minn. Iowa and Wisc., p. 537, Plate 5A, Fig. 4b (not 4a). Also MEEK and WORTHEN, 1866; Geol. Rep. Illinois, Vol. III., p. 467, Plate 16, Fig. 6.

A large species of the type of *P. planus*. Calyx elongate, very large in proportion to the length of the arms. Dorsal cup once and a half as high as wide, almost cylindrical along the radials, but rapidly spreading at the basals, which form a moderately deep pentangular basin with its upper angles slightly curving upwards; the lower margins projecting outward and forming a conspicuous rim around the edge, which often is twice as wide as the column. Plates quite thin and perfectly smooth; the radials slightly thickened along the median line.

Height of basal cup almost one half the length of the radials, its upper edges very thin, and overlapping the lower edges of the radials; interbasal sutures obsolete. Radials about once and a half as long as wide; the sides parallel or very slightly constricted at the top and bottom; the lower face convex, the upper angles scarcely truncated. The lower faces of the radials and the upper faces of the basals in some specimens contain tooth-like projections fitting into each other like interlocking sutures. Radial facets semi-circular, occupying nearly half the width of the plates, and filled completely by the costals, which are subtrigonal, with concave upper faces. Arms from ten to twelve to the ray, comparatively short, rather thin, and very little tapering. The arm plates moderately short and slightly waving. Pinnules long and in close contact laterally. Of the ventral disk only the middle plate of the first interrarial row has been observed, which is comparatively small and subtrigonal. The two proximal joints of the column circular.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the Illinois State collection, Springfield.

Remarks. — This species was confounded by Owen and Shumard, and also by Meek, with *P. planus*, from which it differs in the larger size, the proportionally much smaller and thinner arms, the projecting rim of the basal cup, and in the undulated basi-radial suture lines.

Platycrinus graphicus HALL and WHITE.*Plate LXXI. Fig. 7.*

1863. HALL and WHITFIELD; 17th Rep. N. Y. State Cab. Nat. Hist., p. 55; and 1875, Geol. Surv. Ohio Vol. II., Part II., p. 166, Plate 11, Fig. 2.
 1881. W. and S.; Revision, Part II., p. 72 (Proceed. Acad. Nat. Sci. Phila., p. 246).
 Syn. *P. richfieldensis* HALL and WHITE.; 1875, Geol. Surv. of Ohio, Vol. II., Part II., p. 167, Plate 11, Fig. 1.

Below medium size. The known specimens of this species are badly crushed, and it is impossible to give the form and proportions of the calyx, but probably the dorsal cup was moderately short and rounded at the base. The plates are thin and without ornamentation.

Basal cup apparently deep, its height being probably equal to half the length of the radials. Radials wider than long, subquadrangular, thickened in the middle, the upper faces of the limbs very slightly sloping, and but little excavated for the facet, which faces upwards, and occupies half the width of the plate. Costals rather large, the upper angle sharply pointed, the upper sloping faces distinctly concave. Distichals free from their origin, considerably narrower than the costals, a little longer than wide. Arms four to the ray, rather delicate, the four or five lower joints wedge-form and alternately arranged, the succeeding ones arranged in two series and subquadrangular; all joints moderately long. The pinnules in adult specimens in contact laterally. Structure of ventral disk unknown. Column joints nearly circular, angular around their edges. The column is composed of rather long joints, which alternate with shorter ones, from which we infer that this species possessed internodal joints.

Horizon and Locality.—Shales of the Waverly group, Richfield, Summit Co., Ohio.

Type in the New York State Cabinet at Albany.

Remarks.—The specimen figured by Hall and Whitfield as *P. richfieldensis* undoubtedly represents an immature specimen of *P. graphicus*. The authors admit the strong resemblance of the two forms, but separate them upon the arm structure. They described the arms of *P. richfieldensis* as being “composed of a double series of obtusely wedge-form plates in the lower [upper] part,* the sharp or narrow edges of which extend nearly

* The description says “lower part,” which obviously is meant for *upper* part, and “upper part” in the next line for *lower* part.

across the arm; in the upper [lower] part the arm plates are proportionally longer, and extend entirely across, but separating very slightly the two adjacent plates on the opposite side, making a single range of plates, with their longer faces alternately on opposite sides." This is exactly the condition of the arms in every young *Platycrinus* when it enters the biserial stage.

***Platycrinus Sampsoni* S. A. MILLER.**

Plate LXX. Fig. 10.

1891. S. A. MILLER; Geol. Surv. Missouri, Bull. 4, p. 13, Plate 1, Fig. 11.

A large species of a very unusual form. Dorsal cup cylindrical almost throughout its full length, perhaps a little narrower at the upper end; the base broadly truncated. Plates thin and smooth, the suture lines very slightly grooved. The basal cup resembles a very low disk with nearly erect sides; it is very broadly truncated at the bottom, the sides slightly expanding; the upper faces form an almost straight line around the cup, the angles being so obscure as to be scarcely perceptible; height of the cup equal to a little more than one third the length of the radials; the inter-basal suture lines barely visible. Radials of unequal size, some of them much wider than others, the widest ones about once and a half as wide as long, the narrow ones almost twice as long as wide; the sides parallel. Facets surrounded by a projecting rim; they are narrow, moderately deep, and directed upwards. All other parts unknown.

Horizon and Locality. — Upper Burlington limestone, Burlington, Iowa, and Sedalia, Mo.

Type in the collection of Mr. Sampson.

Remarks. — Described by Miller from a natural cast, but the species is so remarkable that it is readily identified. We possess of it a nearly perfect dorsal cup from which our description was made.

Platycrinus æqualis HALL.*Plate LXXI. Figs. 4a, b, and 5.*

1861. HALL; Descrip. of New Spec. of Crinoids, p. 17.
 1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 456, Plate 3, Fig. 8.
 1881. W. and SP.; Revision, Part II., p. 70 (Proceed. Acad. Nat. Sci., Phila., p. 244).
 Syn. *P. batiola* S. A. MILLER; Geol. Surv. Missouri, Bull. 4, p. 22, Plate 3, Figs. 1 and 2.

Calyx of medium size, the arms proportionally long. Dorsal cup bell-shaped, rounding below to near the column facet, which is distinctly elliptic and somewhat protuberant, giving to the sides of the base just above a slightly concave outline; the radials a little convex, and more or less spreading to the facets, which are surrounded by a thickened rim. Plates a little thicker than in the preceding species, moderately convex, and without ornamentation. The basi-radial and interbasal suture lines generally forming broad, shallow depressions.

Basal cup deep, its height about two thirds the length of the radials, somewhat quinquelobate as seen from below, a little bulging in a radial direction, depressed interradially; the upper margin slightly beveled, producing a moderate constriction along the suture line. Radials quite thin at their edges, thickened in the middle, a little longer than wide, and usually wider at the upper end than at the lower; the superior angles slightly truncated. The facets subquadrangular, deep, rather long, their width equal to one half the transverse dimension of the plates. Costals trigonal, very small, occupying but one third the width of the facets, which enclose one or both distichals. Distichals and palmars twice as wide as long, free above their first plates. Arms varying from six to ten to the ray; long, widest at the middle, gradually tapering to the tips, the dorsal surface somewhat flattened. The three or four proximal arm pieces cuneate and singly arranged, the biserial ones above shorter and presenting a curious flexure or geniculation in the middle, so as to give a zigzag appearance to the transverse sutures between them. Pinnules in close contact, and composed of joints three to four times as long as wide. Ventral disk unknown. Column elliptic, the long diameter of the joints more than twice as great as the shorter one.

Horizon and Locality.—Upper Burlington limestone, Pleasant Grove, and Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks.—The peculiar form of the dorsal cup, the elliptic projecting column facet, combined with the arm structure, distinguish this species readily from all others known to us.

TRUNCATULUS GROUP.

Plates without ornamentation; costals two.

Platycrinus truncatulus HALL.

Plate LXVII. Figs. 11a, b, and Plate LXXI. Figs. 18a, b.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 538.

1881. W. and S.; Revision, Part II., p. 75 (Proceed. Acad. Nat. Sci. Phila., p. 249).

A small species. Dorsal cup basin-shaped, more than once and a half as wide as high, broadly truncate at the bottom, the sides slightly convex and moderately spreading. Plates heavy, considering the small size of the species; surface smooth; suture lines not grooved and difficult to see. Arms unknown.

Basal cup very shallow, only the upper angles and the extreme upper margins of the sides visible in a side view; these curve abruptly upwards by a sharp angle; the lower face perfectly flat, except that the column facet is surrounded by a small circular ridge; the interbasal suture lines somewhat elevated. Radials one fourth wider at the upper end than at the lower, the width of the lower face equal to the length of the lateral faces, the upper angles distinctly truncated. Facets narrow, semicircular, the excavation limited entirely to the outer edges of the plates, the inner edges forming a straight line. Costals two, the lower plate shorter than the upper, twice as wide as long and quadrangular, the upper one hexagonal, its upper angle truncated, and the distichals separated by a wide gap. Distichals two, as long as wide, the second axillary indicating another division above. Ventral disk slightly convex, the plates almost flat. Orals rather regularly arranged, and small. The ambulacral pieces rising above the general level; very narrow, small, and as regularly arranged as in any of the recent Crinoids. Interambulacral plates numerous; the first of the regular sides very large, its sides resting against the first costals, the two at the sides, which in this species are extremely small, touch but slightly the second; the plates above very minute. At the anal side there are three plates abreast; the middle

one narrower and shorter than the corresponding plate of the other sides, the adjoining ones a little smaller. The succeeding plates are small, and form a tubular inflation which contains the anus. Of the column only the six proximal joints have been observed, all of which are circular.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — This and the succeeding species differ from all other *Platycrinini* known to us in having two costals. That this is not an abnormality, but a constant character in this species, is proved by the fact that we observed the same thing in four specimens and in all the rays. The species also departs from others in having but one interrarial in contact with the radials, and the stem joints are apparently circular. If we were certain that the latter structure also occurred in *P. eriensis*, we should propose for the two species a new generic name.

***Platycrinus eriensis* HALL.**

1862. HALL; 15th Rep. N. Y. State Cab. of Natural History, p. 119, Plate 1, Fig. 1.

A small species, the dorsal cup scarcely more than 5 mm. in height, the arms three times as long. Basals anchylosed, curving gently upwards; the column facet comparatively large, bordered by a thickened rim. Radials a little wider than long, slightly spreading; the interrarial sutures marked by a sharp line. The median line of the plates more prominent below the facets. Facets nearly one third the width of the plate. Costals two, the first quadrangular, the second pentangular, giving off two simple arms. Arm joints uniserial, as far as preserved, strong, subangular, thickened at their extremities, and supporting strong pinnules. Surface of plates granulose. The strong subangular joints of the arms, and the strong pinnules, are marked characters.

Horizon and Locality. — In the shales of the Hamilton group, near Hamburgh, Erie Co., N. Y.

Type supposed to be in the N. Y. State Cabinet of Natural History, Albany.

Remarks. — To judge from the arm structure, the description was made from a very young specimen; but it is interesting as having two costals like *P. truncatulus*. Our description is made after Hall.

SARÆ GROUP.

The plates of the dorsal cup smooth or obscurely granulose; the inter-basal sutures raised into ridges by excessive secretion of calcareous matter during anchylosation; the stem with internodal joints.

Platycrinus Saræ HALL.

Plate LXIX. Fig. 7, and Plate LXX. Fig. 1.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 673, Plate 18, Fig. 4.

1881. W. and S.F.; Revision, Part II., p. 74.

Syn. *Platycrinus Georgi*, HALL; Suppl. Geol. Rep. Iowa, p. 82.

Syn. *P. prattenanus* M. and W.; Geol. Rep. Illinois, Vol. II., p. 264, Plate 20, Fig. 2.

Syn. *P. monroensis* WORTHEN; *ibid.*, Vol. VII., p. 306, Plate 30, Fig. 9.

Dorsal cup goblet shaped, gibbous in the middle, broadly truncate at the base. Surface of plates smooth, or covered with a few obscure ridges passing out from the facets to the lower angles of the radials.

Basals forming a saucer-shaped dish, occupying fully one third the height of the dorsal cup; the lower end broadly truncated, the outer margin projecting and forming a rim; the lower face a little concave, and wider than the upper stem joints. Interbasal sutures distinctly elevated above the general surface, and formed into ridges. Radials quadrangular, as wide as long, and as wide at the lower end as at the upper. Facets deeply indented, embracing the costal and one or both distichals. Costals very small, triangular. Distichals once and a half as wide as long, giving off an arm to the outer side of the plates, their inner sides two palmars with two arms, making six arms to the ray. Arms biserial from the second or third joint, of moderate size; the tips somewhat tapering. Pinnules very long and closely set; their joints more than twice as long as wide. Structure of the ventral disk unknown. Column very slightly oval; composed of nodal and internodal joints, the former wider and higher than the internodals. Whether the upper and lower faces of the joints have transverse ridges could not be ascertained from the specimens.

Horizon and Locality. — St. Louis group; St. Louis, Mo., and Jersey Co., Ill.

Types in the (Worthen) Illinois State collection, Springfield.

Remarks. — *P. Saræ* was described from a very large, somewhat crushed specimen, showing indistinct traces of ornamentation; *P. Georgii* from a dis-

torted, much smaller specimen, with smooth plates. In the type of *P. prattenianus*, which preserved its natural form, the rim around the base projects more than in the type of *P. Saræ* as figured by Hall, but the base is not correctly represented in that figure. *P. monroensis* is a very young specimen in which the arms are as yet uniserial, zigzag, and the plates wedge-form, with nothing to indicate that it differed from the preceding forms.

Platycrinus Huntsvillæ TROOST MS.

Plate LXXIII. Figs. 6, 7a, b, 8, 9, 10, 11, 12.

1849. TROOST; Proceed. Amer. Ass. Adv. Sci. of 1849, p. 61 (without description).
 Syn. *Platycrinus penicillus* M. and W., 1860; Proceed. Acad. Nat. Sci. Phila., p. 380; also Geol. Rep. Illinois, Vol. II., p. 266, Plate 19, Figs. 6a, b, c.
 Syn. *Platycrinus plenus* M. and W., 1860; Proceed. Acad. Nat. Sci. Phila., p. 380; also Geol. Rep. Illinois, Vol. II., p. 267, Plate 20, Fig. 3.
 Syn. *Platycrinus alabamensis* S. A. MILLER, 1891; Adv. Sheets 17th Rep. Geol. Surv. Indiana, p. 50, Plate 9, Fig. 5.

An extremely variable species of the type of *P. Saræ*, varying considerably in the form and ornamentation of the calyx plates and in the number of arms; but readily recognized by the peculiar and unique form of the brachials, and the presence of a large pinnule upon the first distichals and first palmars. Dorsal cup generally a little wider than high, cup or bowl-shaped; the sides in most of the specimens nearly straight, curved longitudinally, but sometimes distinctly convex and constricted at the arm regions; base of the cup rather broadly truncated.

Basals forming a short saucer-shaped cup with a flattened or slightly concave lower face, which exceeds the width of the stem at the upper end; the interbasal sutures visible by moistening the specimens, their lines highly elevated above the surface, and formed into ridges which at the lower edges of the cup terminate in small tubercles. Radials subquadrangular, about as wide as long in mature specimens, proportionally a little shorter in the younger ones; the sides very slightly expanding; the superior lateral angles distinctly truncated. Facets directed upward; small, occupying only one third the width of the plates, and extending but a short distance downward. Costals trigonal, much wider than long, occupying the full width of the facets; the superior faces concave, and indented at the median portions for the reception of small processes passing out from the lower edges of the distichals, and forming waving sutures, which resemble those of the Ichthyocrinidæ. Similar suture lines occur between the distichals, palmars, and

between the five or six proximal plates of the arms. Distichals two, directed upwards, rather large, the first nearly once and a half as wide as long, and pinnule-bearing; the second a little longer and axillary; their upper angles acute. The distichals generally support a single arm on either side; occasionally, however, one of the plates—or both of them—gives off an arm from its outer side, and two palmars with two arms from the inner one. The two palmars, when represented, are as large as the distichals, but proportionally higher. Arms free above the first distichals, from four to six to the ray, the number often varying in the same specimen; rather heavy, especially at midway, where in adult specimens they are often twice, and even three times, as thick as near the calyx. They are biserial at the upper end, uniserial to the fifth or sixth joint; the latter plates, which are moderately long and wedge-formed, are alternately arranged and gradually interlock. The distichals and the cuneate arm pieces are constricted in the middle, and provided laterally with sharp, thorn-like projections at their upper and lower ends, which sometimes extend to the biserial portions of the arms. Pinnules stout, long, closely packed, and composed of long joints; the one from the first distichal stouter than the rest, and less erect. Of the ventral disk only the middle plate of the interambulacral series has been observed; it is visible in a side view, and crowned by a small tubercle or short spine. Stem joints elliptical and moderately long; the nodal ones at the lower part of the stem quite prominent, and their margins in well preserved specimens surrounded by bead-like nodes or short thorns.

Horizon and Locality. — St Louis limestone, Huntsville, Ala., and Hardin Co., Ill. At Huntsville it is found about sixty feet below the *Pentremites Godoni* beds, where it occurs in small pockets in large numbers.

Types in the collection of Wachsmuth and Springer.

Remarks. — The name *Platycrinus Huntsvillæ* appears in Troost's List of the Crinoidea of Tennessee, published in the Proceedings of the American Association for the Advancement of Science, Cambridge meeting, 1849, without figure or description, and has ever since been applied by palæontologists and collectors to the only form of *Platycrinus* occurring near Huntsville. We are aware that this does not establish Troost's name.

In 1860, Meek and Worthen described as *P. penicillus* and *P. plenus* two specimens from Hardin Co., Ill., both of which we have examined, and which we have reason to regard as aberrant forms of *P. Huntsvillæ*. Looking at the two specimens alone, one would say at first sight that they are distinct

species, and different from *P. Huntsville*; but upon examining the arm structure, basals and stem, it will be found that they differ only slightly in the form of the calyx and the matter of ornamentation, one being cup-shaped and ornamented, the other globular and smooth. On comparing them with the specimens from Huntsville, it will be seen that similar variations occur among them also, along with all sorts of transition forms. The two forms were evidently regarded by Meek and Worthen as specifically distinct from *P. Huntsville*, for the Worthen collection contains a large number of fine specimens from Alabama, labeled *P. Huntsville*.

In 1861, S. A. Miller described under *P. alabamensis* a small, crushed specimen from Huntsville, but neither figure nor description gives a correct idea of the species, and he did not state in which division of the "Subcarboniferous rocks" it was found. He did not define the peculiarities of the arm structure, which are so characteristic of *P. Huntsville*, and indeed the description would apply equally well to other forms. It is very curious that Meek and Worthen described the arm structure, but did not represent it in their figure; while on the other hand Miller indicated it in his figure without mentioning it in the description. Priority would give the first of Meek and Worthen's names to the species, if any of the above descriptions are to apply; but this would lead to confusion, and would establish an aberrant form for the typical one. Under all the circumstances, we have thought best to redescribe the species under Troost's name, thus giving the credit to the pioneer naturalist who discovered, recognized, and called attention to the new form.

For the last ten years one of us has spent a month or two every year at Huntsville, and obtained of this species over a thousand specimens, in all kinds of preservation, and of all sizes, from 9 mm., including arms, to 50 mm., and intermediate stages, which give most valuable information upon the variability of this species and the Crinoids generally, and also upon the changes due to growth. If we were following the practice of some palæontologists, we would be able by picking out individual specimens to make out of this one species half a dozen or more. In some specimens the plates appear altogether smooth, without showing in other parts any evidence of erosion or weathering; while others have well marked nodes, separate or confluent. In still others the proportion of height to width of the calyx varies considerably. All these specimens, however, are characterized by certain peculiarities by which they can be identified at once as be-

longing to one species. In all of them there appear around the stem three conspicuous nodes, which are continued to the upper edges of the basal disk; and in all may be seen the unique articulation between the lower brachials and arm plates; while the inflation of the arms at their middle portions is a frequent character in mature specimens. But far more striking are the differences caused by growth. Comparing the smaller specimens with the larger ones, it will be found that the arms in the smallest or youngest ones are not only uniserial throughout, but decidedly zigzag, and that their joints are proportionally much longer than those of the adult. In more advanced specimens the tips of the arms are biserial, and the biserial part extends downward, as the specimens grow larger, by the introduction of additional joints at the top, and the progressive interlocking of the cuneate plates. The modifications here exhibited, and due beyond all question to individual growth alone, are so remarkable, that without a knowledge of the ontogeny of the Crinoids, the earlier stages of this species might readily be taken as representatives not only of different genera, but even of different groups.

Platycrinus boonvillensis S. A. MILLER.

Plate LXXII. Figs. 8a, b, and 9.

1891. S. A. MILLER; Bull. 4, Geol. Surv. Missouri, p. 8, Plate 1, Figs. 1 and 2.

A rather large species of the type of *P. burlingtonensis*. Calyx to the top of the radials bowl-shaped, wider than high, slightly pentagonal as seen from above. Plates moderately heavy, the surface smooth, or nearly so; the basi-radial and interradial sutures grooved. Basals closely anchylosed, the lines of union elevated into ridges; they form a low, rapidly spreading basin, distinctly pentangular at the upper end, broadly truncated at the lower, the bottom deeply excavated so as to form a rounded, rugose rim around the column. Column facet circular, occupying one half of the width of the concavity, its face covered with radiating striæ. Radials a little wider than long, gradually expanding upwards, slightly more elevated along the median line, and somewhat beveled toward the sutures. The facets occupy less than half the width of the plates; they are shallow, directed upwards, and surrounded by a projecting rim.

Horizon and Locality. — Lower part of Warsaw limestone; Boonville, Mo., and Spurgen Hill, Ind.

Types in the collection of Mr. Sampson.

Remarks. — Described from the basals and radials, all the other parts being unknown. The interbasal sutures, which are represented in both of Miller's figures, are not visible in the specimens; but the places where they should be are indicated by elevated ridges.

Platycrinus niotensis M. and W.

Plate LXXI. Fig. 9.

1865. MEEK and WORTHEN; *Proceed. Acad. Nat. Sci. Phila.*, p. 162; and *Geol. Rep. Illinois*, Vol. III. p. 513, Fig. 3.

1881. W. and SP.; *Revision, Part II.*, p. 73 (*Proceed. Acad. Nat. Sci. Phila.*, p. 247).

A very small species. Calyx below the summit of the radials cup-shaped, the sides distinctly rounded in the type, scarcely convex in other specimens; the base short, basin-shaped, broadly truncated at the bottom. Plates smooth and slightly convex, the basi-radial and interrarial sutures distinct, but not grooved.

Basals forming a short cup of one third the height of the radials, the lower rim somewhat projecting outward, the lateral margins of the plates slightly raised toward the suture lines, and forming indistinct ridges and a small projection at the lower extremity of each suture. Radials large, as long as wide, or a little longer, widening moderately from below upwards; subquadrangular, the superior angle slightly truncated by the interrarial plates. Facets shallow, and occupying about half the width of the plates. Costals trigonal, rounded at the lower end, completely filling the facets. Distichals two, both one third wider than long. Arms four to the ray, rather heavy throughout, and biserial from the second or third plate. Column near the base compressed and tortuous, being composed of alternate thick and thin elliptic joints.

Horizon and Locality. — Keokuk group; Niota, Ill., Indian creek and Canton, Ind.

Type in the Illinois State collection.

Remarks. — The figure of the type specimen in the Illinois Report is somewhat misleading; the base is made too high and the radials too short. It also appears as if one of the rays had but three arms, while it actually has four, like the other rays. The species is closely allied to *P. Sarae*, but is considerably smaller, and its arms less numerous and proportionally stronger. It resembles still closer *P. bonoensis*, but that has five to six arms to the ray, and the arms are shorter.

Platycrinus bonoensis WHITE.*Plate LXIX. Fig. 6.*

1878. WHITE; Proceed. Acad. Nat. Sci. Phila., p. 30; and 1880, U. S. Geol. Surv. Terr. by Hayden, Contr. to Paleont. No. 5, p. 160, Plate 40, Fig. 5.
 1881. W. and SP.; Revision, Part II., p. 70 (Proceed. Acad. Nat. Sci. Phila., p. 244).
 Syn. *P. æternalis* S. A. MILLER, 1891; Geol. Surv. Missouri, Bull. 4, p. 11, Plate 1, Fig. 8.
 Syn. *P. caducus* S. A. MILLER, 1892; Adv. Sheets 18th Rep. Geol. Surv. of Indiana, p. 13, Plate 2, Fig. 13.

Closely allied to the preceding species, but having five to six arms to the ray instead of four, and these are proportionally shorter, more closely packed, and heavier. Dorsal cup wider than high, bowl-shaped, a little spreading, the margins of the plates slightly beveled, giving to the central portions a slight convexity. Surface without ornamentation.

Basals proportionally small, forming a shallow basin, broadly truncated below and excavated at the bottom, the sides somewhat constricted so as to form a rounded projecting edge around the lower margins; the interbasal suture lines slightly elevated. Radials wider than long, gradually expanding upwards, the upper angles truncated, deeper at the anal side. Facets from one half to two thirds the width of the radials; semicircular. Costals small, trigonal, rarely covering the full width of the facets, and the distichals abut against the radials. First distichals once and a half as wide as long, the axillary one a little wider and somewhat higher. The latter gives off an arm to the outer side of the ray, and supports at the inner two palmars with two arms, making three arms to each subdivision, or six to the ray, exceptionally five. The arms are stout, especially in the middle, and quite short; they are uniserial to the fourth plate, beyond this biserial. Column slightly elliptic, and twisted.

Horizon and Locality. — Uppermost part of the Keokuk group and lower beds of the Warsaw limestone, Bono, Lawrence Co., Ind., and Boonville, Mo.

Types in the collection of W. F. E. Gurley, and R. A. Blair at Sedalia, Mo.

SUBSPINULOSUS GROUP.

Basal cup almost as high as the radials, subcylindrical. Surface of plates smooth or ornamented.

Platycrinus subspinulosus HALL.

Plate LXVI. Figs. 2a, b, and Plate LXX. Fig. 9.

1860. HALL; Suppl. Geol. Rep. Iowa, p. 81, with diagrammatic figure.

1881. W. and Sp.; Revision, Part II., p. 75 (Proceed. Acad. Nat. Sci. Phila., p. 249).

Below medium size. Height of dorsal cup about equal to the width at the lower edges of the radial facets, where the section is distinctly quinquelobate, owing to a thickening of the radials at the median line toward the facets. Plates thin at their edges, but quite heavy at the middle; covered with short spines or conspicuous nodes, which upon the basal cup are quite irregularly distributed, some of them being thickly set and confluent, others dispersed, especially in the upper portions of the cup. The spines upon the radials are arranged in three rows, two of them proceeding from the facets diagonally to the lower angles of the plates, the other vertically to the basal cup. Interradial sutures at the bottom of a shallow angular depression, not grooved; interbasal sutures obsolete.

Basal cup subcylindrical, a little widest at the upper end; the column facet projecting and distinctly elliptic. Radials slightly spreading, nearly once and a half as long as wide; the facets horse-shoe shaped, longer than wide, profoundly excavated, and having a deep, rounded notch at the upper end. Structure of arms and ventral disk unknown.

Horizon and Locality.—Upper Burlington limestone, Burlington, Iowa.

Type in the Illinois State Museum of Natural History.

Platycrinus Davisi W. and Sp. (nov. spec.).

Plate LXX. Fig. 14.

Below medium size. Dorsal cup depressed bell-shaped, a little wider than high, rounded at the base, the sides concave along the basal cup, convex along the radials. Plates rather heavy; the suture lines very slightly grooved.

Basal cup deep, wide at the bottom, its height equal to two thirds the length of the radials, its lower face quinquelobate, having five short, rounded nodes, interradially disposed and extending over the whole width of the plates; they are separated by a well defined groove, giving to the base the appearance of being quinquepartite. Attachment for the stem circular and

slightly depressed. Radials moderately spreading and somewhat irregular in form; the two posterior ones fully as wide as long, the others a little longer; the median portions of the plates abruptly raised, forming a quadrangular elevation of which the margins are parallel to the edges of the plates. Costals subtrigonal, rather short. Ventral disk convex, flattened at the summit. The orals very large, the posterior one larger than the four others; the latter elongate, at the four regular sides of the calyx resting against the first row of interradials, of which the middle one is wedged in deeply between the radials. The middle plate of the anal side is much wider, and supports a number of small plates which form the anus. Ambulacral plates few upon the disk. Anal opening excentric, directed upwards. Structure of arms unknown.

Horizon and Locality. — Lower Burlington limestone, Hannibal, Mo.

Type in the collection of Wachsmuth and Springer.

Remarks. — This species resembles *P. subspinosus* Hall, but differs in the form of the calyx and in the surface markings.

The specific name is in honor of Rev. John Davis, of Louisiana, Mo., to whom we are indebted for the type specimen.

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Platycrinus allophylus S. A. MILLER.

Plate LXXI. Fig. 17.

1891. S. A. MILLER; Bull. 4, Geol. Surv. Missouri, p. 9, Plate 1, Figs. 3 and 4.

A small species, in its form unlike any other *Platycrinus*. Dorsal cup slender, once and a half as high as wide, cylindrical to the top of the basals, then expanding gracefully to the arm facets; the lower face broadly truncated. Surface of plates apparently smooth; their margins toward the basi-radial and interradial sutures slightly beveled; the interbasal sutures rarely visible. Basals as long as the radials, forming a cylindrical cup with a short expanded rim around the lower end, the bottom truncated, and slightly impressed for the reception of the first stem joint, which occupies less than half the diameter of the lower face. Radials longer than wide, moderately expanding above, rounded along the back, depressed at the sides, their facets projecting. The latter occupy fully one half the width of the radials, and more than a third their length; they are semicircular, are deeply notched at the upper end, and directed outward almost horizontally. Costals short and axillary;

the interradial plates erect. Ventral disk convex; covered with spinous plates. Column small, obscurely elliptical.

Horizon and Locality. — Chouteau limestone; six miles southeast of Sedalia, Mo.

Types in the collection of Mr. Sampson.

AMERICANUS GROUP.

Dorsal cup rather short and but slightly spreading; base nearly flat; plates ornamented by coarse granules or rows of confluent nodes.

Platycrinus americanus O and SH.

Plate LXXV. Figs. 10, 11, 12, 13a, b, c.

1852. OWEN and SHUMARD; U. S. Geol. Surv. Wisc., Iowa and Minn., p. 594, Plate 5B, Figs. 1a, b.

1881. W. and SP.; Revision, Part II, p. 70 (Proceed. Acad. Nat. Sci. Phila., p. 244).

Syn. *Platycr. truncatus* HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 537.

(?) Syn. *P. Broadheadi* S. A. MILLER; 1891, Geol. Surv. Missouri, Bull. 4, p. 21, Plate 2, Fig. 15.

Calyx subglobose, a little higher than wide. Dorsal cup more than once and a half as wide as high, slightly spreading, the base broadly truncated. Height of ventral disk about equal to that of the dorsal cup. Plates ornamented by coarse granules or irregular nodes, arranged in concentric lines around their margins, covering the entire surface. Edges of the plates beveled, and the basi-radial and interradial suture lines channeled.

Basals forming almost a plane, rarely more than their beveled edges visible in a side view; the column facet very slightly depressed; interbasal sutures indeterminable. Radials a little spreading, one fourth wider than long; the outer ends of the upper faces moderately sloping, except toward the anal side where they form a deep and broad notch. Facet semicircular; the notch at the summit very small, if represented at all. Costals rather large, much wider than long; pentangular. Distichals and palmars as long as the costals but narrower, a little constricted across the middle. Arms six to the ray; of moderate size, biserial above the second or third plate from the bifurcation; the joints rather long; the pinnule sockets projecting, especially in young specimens, and the pinnules strong and in contact laterally; the proximal one being given off from the first distichals. Ventral disk hemispheric, the plates convex. Orals large, rather regularly arranged. Ambulacral plates small and not elevated. Interambulacrals three and two; the middle one of the first row longer than wide, that of the anal side much

larger, and wider than long, followed by numerous small pieces forming a protuberance, which is pierced by the anus; the opening directed laterally, Column small.

Horizon and Locality.—Lower Burlington limestone, Burlington, Iowa, Quincy, Ill., and in rocks of the same age throughout Missouri.

Remarks.—Of this species we obtained several very young specimens (Plate LXXV., Fig. 11), in two of which the arms are as yet uniserial throughout, in others biserial only at their tips. In these specimens the arms have a distinctly waving outline, their joints are proportionally longer, shaped like axillary plates, and the sides supporting the pinnules are greatly projecting.

We have examined the type of *P. truncatus* Hall, in the Illinois State collection, and regard the specimen as identical with *P. americanus*, although it has apparently no ornamentation. It agrees with the latter in the form of the dorsal cup, the channeled suture lines, the large and deep notch between the two posterior radials, as well as in the arm structure. Miller's *P. Broadheadi*, in all probability, is also identical with this species; it was described from an imperfect dorsal cup, and neither figure nor description enables us to make a critical comparison.

***Platycrinus tenuibrachiatus* M. and W.**

Plate LXX. Figs. 7, 8.

1869. MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 168; and 1873, Geol. Rep. Illinois, Vol. V., p. 450, Plate 3, Fig. 4a (not 4b).
1881. W. and Sp.; Revision, Part II., p. 75 (Proceed. Acad. Nat. Sci. Phila., p. 249).

Of medium size. Resembling *P. americanus*, but the calyx proportionally wider, and also more discoid. Dorsal cup basin-shaped, three times as wide as high; the base concave, only its upper angles seen in a side view; the sides rapidly spreading, very slightly curving; basi-radial and interrarial suture lines channeled. Surface of plates covered with rugose markings or irregular rows of nodular ridges, parallel to the outer margins of the plates, and forming concentric lines.

Base large, rather flat; the median portion decidedly depressed; the interbasal sutures grooved. Radials uniformly spreading; the upper end nearly one third wider than the lower; the sides a little shorter than the width of the lower face; the upper angles truncated, forming a small but deep notch, which is filled by a hexangular interrarial plate. Facets semi-

circular, occupying one third the width of the plates. Costals subtrigonal, the sloping upper faces concave, and their angle rather sharp. Distichals and palmars once and a half as wide as long. Arms from six to eight to the ray, of nearly uniform size throughout, biserial from their fourth or fifth plate; the joints moderately long, united by slightly waving sutures. Pinnules strong, composed of long joints. Structure of ventral disk unknown.

Horizon and Locality. — Upper Burlington limestone, Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks. — In this species Meek and Worthen included another form, which we have described under the name of *Platycrinus nodostriatus*, and which differs essentially in the form of the basal cup, and in the style of ornamentation.

***Platycrinus brevinodus* HALL.**

Plate LXX. Figs. 2, 5, 6a, b.

1861. HALL; Descr. New Spec. Crin. p. 4, and Bost. Journ. Nat. Hist., p. 286; figured 1872, N. Y. State Museum, Bull. 1, Plate 24, Fig. 5.

1881. W. and Sr.; Revision, Part II., p. 70 (Proceed. Acad. Nat. Sci. Phila., p. 244).

A rather small species. Dorsal cup nearly twice as wide as high, slightly spreading, broadly truncate at the base. Basals proportionally large, disk-like, truncate below, only the extreme upper ends turning upwards, very little concave, and the outer margins surrounded by a row of conspicuous nodes, directed outward and giving to the edges a crenulated outline; the interbasal sutures obsolete. Radials wider than long, a little widest at the top; subquadrangular; the outer ends of the upper face but slightly sloping, except those of the anal side, which form a distinct notch, and support a rather large hexagonal plate. Radial facets shallow, occupying half the width of the plates. Basi-radial and interrarial suture lines grooved. Costals triangular, moderately large, occupying the whole width of the facets. Distichals two, free from the costals up, the first once and a half as wide as long; the second as long as wide. Palmars, when present, but little larger than the succeeding arm plates. Arms four to six to the ray in the same specimen, rather slender and tapering; their proximal ends composed of five to six cuneiform pieces, which gradually turn into biserial above. Pinnules placed somewhat distant. Structure of ventral disk unknown.

Horizon and Locality. — Described from the Keokuk group at Keokuk, Iowa; but occurring also at the same horizon at Indian creek, Montgomery Co., Ind., and in the Burlington and Keokuk transition beds near Burlington.

Type specimen in the American Museum of Natural History, New York.

Remarks. — The Indian creek specimens sometimes have an additional row of ridges passing out to the sides, but otherwise agree with those from Burlington and Keokuk. Their arms also vary from four to six to the ray.

Platycrinus canaliculatus HALL.

Plate LXXV. Figs. 7a, b.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 539.

1881. W. and Sr.; Revision, Part II., p. 71 (Proceed. Acad. Nat. Sci. Phila., p. 245).

Calyx small, a little higher than wide, widest across the base of the radial facets; subovate, slightly truncated at the poles. Dorsal cup once and a half as wide as high, the upper edge slightly inflected. Surface of plates marked by a few rather conspicuous nodes, of which generally twenty occupy the basal disk, two directed to each upper angle of the plate, while two others are parallel with the sides; the latter placed so close to the margins as to give to the edges a serrated outline. The radials have three pairs of nodes passing downward, two of them running obliquely to the lower angles of the plates, the other pair vertically, following the median line. Two other nodes are placed close to the upper ends of the plates, one to each side. Basi-radial and interrarial suture lines canaliculate, and the edges of the plates beveled.

Basals forming a flat disk, of which only the outer edges are seen in a side view; the middle portion has a more or less deep rounded depression, wide enough to contain the top stem joint. Radials one fourth wider than long, very little spreading; the upper angles slightly truncated; the facets semicircular, occupying nearly one third the width of the plates, thickened around the edges. Costals small, trigonal, their upper faces deeply notched. Ventral disk as high as the dorsal cup, distinctly stellate as seen from above. Orals small, rather regularly arranged, forming an elevated area from which the ambulacra pass outward and downward. Covering pieces strongly convex, and conspicuously elevated over the interambulacral spaces, which slope abruptly from the orals at an angle of nearly sixty degrees, and form deep trigonal depressions containing three plates each: a very large and nodose lower one, and two smaller plates above. The two plates at the sides of the larger one are narrow, and curve abruptly outward. Arms and column unknown.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.
Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — This species was described from a poor specimen, in which only the basals and radials were preserved. The markings of the type specimen are less distinct than in the one we figure, but there can be no doubt that both belong to the same species. The form and ornamentation of the dorsal cup resemble very closely *P. brevinodus* Hall, from the Keokuk group, and it is doubtful if the two species are not identical. A satisfactory comparison cannot be made as long as nothing is known of the structure of the ventral disk of that species, and in this nothing of the arm structure.

Platycrinus asper M. and W.

Plate LXVIII. Figs. 9a, b.

1861. MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 129; also Geol. Rep. Illinois, Vol. III., p. 468, Plate 18, Fig. 9.
 1881. W. and SP.; Revision, Part II., p. 70 (Proceed. Acad. Nat. Sci. Phila., p. 244).
 (Not *P. asper* Goldfuss = *Storthingocrinus asper*).

Below medium size. Dorsal cup twice as wide as high, gradually spreading, the sides nearly straight; the base depressed, and abruptly and deeply excavated so as to form a narrow, thickened rim with an undulating or roughened surface. A similar rugose rim borders the lower and lateral margins of the radials, leaving a small quadrangular depression beneath the facets. Sides of the basi-radial and interradian sutures broadly beveled; the interbasal suture lines distinctly grooved.

Basals rather large, only their outer margins seen in a side view; the excavated inner part considerably wider than the diameter of the column. Radials wider than long, widening moderately upwards, the lower face straight, the outer ends of the upper face slightly sloping; facet semicircular, its width equal to half the width of the plate, and slightly projecting. Costals subpentangular, the sloping upper faces concave. Distichals once and a half as wide as long, narrower than the costals, and not in contact laterally. Palmars nearly as large as the distichals and of the same general form. Arms of medium size, four to six to the ray—six being probably the normal number—composed above the axillaries of sharply cuneate pieces, which gradually turn into biserial; the costals, distichals, and palmars transversely grooved at the middle. Ventral disk high, bulging, composed of rather large, slightly convex pieces; the ambulacral plates

small, slightly projecting near the arm bases. The interambulacral spaces are formed of five plates, of which the middle one of the first row is twice as large as the others, and hexagonal. The two or three upper stem joints circular, the succeeding ones elliptic.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

SCULPTUS GROUP.

Basals and radials forming a deep cup; the base high and distinctly convex; the plates ornamented by transverse lines of confluent nodes following the margins of the plates. Radial facets small; arms moderately large.

Platycrinus sculptus HALL.

Plate LXVIII. Fig. 5, and Plate LXXV. Fig. 8, 9.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 536, Plate 8, Fig. 11.

1881. W. and SP.; Revision, Part II., p. 75 (Proceed. Acad. Nat. Sci. Phila., p. 249).

Syn. *Platycrinus rotundus* S. A. MILLER; Geol. Surv. Missouri, Bull. 4, p. 20, Plate 2, Figs. 11 and 12.

Dorsal cup of medium size, in very mature specimens higher than wide, a little wider than high in small ones, growing proportionally higher with age; the sides evenly convex from the stem upwards. Surface of plates ornamented with rows of confluent nodes or undulated ridges, the base being covered by three to five rows, running parallel to the upper margins of the plate; five others radiate from the column to the upper angles. Similar rows, varying from three to six, according to the age of the specimen, follow the margins of the radials, and three rows proceed from the facets to the lower face; two of these directed diagonally to the outer angles, the middle one, which is sometimes unrepresented, placed vertically.

Base from one fourth to one third as high as the dorsal cup, basin-shaped; the median portions slightly truncated and a little excavated; the upper margins of the plate somewhat beveled, giving to the basi-radial sutures a slight depression. Radials quadrangular, the lower edge convex, the sides very slightly spreading, the upper face but little sloping to the angles. Facets small, semicircular, directed obliquely upwards, occupying but one third the width of the plates, and only a small portion of their height. Costals small, trigonal, sometimes narrower than the facets, so that portions of the first distichals come in contact with the radials. First dis-

tichals small, twice as wide as long, placed obliquely, the two of the same ray connected laterally. Second distichals considerably wider than the first, but not longer. Palmars and post-palmars of the form of the distichals, but somewhat smaller. Arms eight to the ray; cylindrical, moderately strong, biserial from the start; the upper edges of the plates forming a small thickened ridge projecting over the lower margin of the succeeding plate. Structure of ventral disk unknown. Column small for the size of the specimens, elliptical and twisted; the transverse articular ridge of apposed faces prominent, with a distinct fossa at each side.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — The ornamentation in some specimens is more conspicuous than in others. The length of the radials and the depth of the basal cup are also quite variable. The latter, however, may be understood by considering that the rows of nodes surrounding the margins of the plates represent lines of growth, and increased in number with age, and as the plates grew faster longitudinally than horizontally, they became in the older specimens proportionally longer.

This species, with slight modifications, apparently occurred also at Lake Valley, New Mexico. A specimen from that locality (Plate LXVIII., Fig. 5) shows the structure of the ventral disk, which had not been observed in any from Burlington, but as the arms are not preserved there is some doubt as to its specific identity. It agrees with the Burlington specimens perfectly in the ornamentation of the plates, but the second joint of the stem is decidedly elliptic, the radials somewhat more convex, producing slight angular depressions at the basi-radial and interrarial sutures, the upper angles of the plates are more inflected, and the facets apparently a little deeper. The ventral disk is depressed-hemispherical, decidedly flattened at the top, the posterior side somewhat bulging, the orals comparatively small and very slightly convex, the covering pieces tuberculous. There are but three inter-ambulacral plates to each side, of which the middle one is extremely large, and erect except that the upper end curves abruptly inward; those of the regular sides are subtrigonal in outline, but actually hexagonal; the anal one wider, subquadrangular, and the top slightly excavated to form the anal opening, which points upward.

Platycrinus glyptus HALL.*Plate LXVII. Figs. 4, 5.*

1861. HALL; Descriptions of New Crinoids, p. 16.

1881. W. and SP. (var. of *P. sculptus*); Revision, Part II., p. 71 (Proceed. Acad. Nat. Sci. Phila., p. 245).

As large as the preceding species, and resembling it in the form of the calyx and style of ornamentation; but the arms more numerous, more delicate, and comparatively shorter. Dorsal cup goblet-shaped, height and width about equal, in very large specimens the height somewhat greater. Surface marked by irregular, undulated ridges or rows of obscure nodes, following the margins of the plates, and increasing in number in the growing Crinoid; the radials traversed by two diagonal ridges from the facets to the lower angles of the plates. Basi-radial and interbasal sutures canaliculate.

Basal cup comparatively deep, its height equal to one third the height of the calyx to the arm bases, the lower end rather abruptly truncated and slightly excavated; interbasal sutures faintly visible. Radials longer than wide; the lower faces convex — those meeting the interbasal sutures distinctly angular — and slightly beveled along the edges; the sloping upper faces forming a rather deep notch, which at the anal side is twice as wide as at the other sides, and filled by a rather large, lozenge-shaped plate. Radial facets small, occupying scarcely a third of the width of the plates, and extending but little downward. Costals subtrigonal, moderately large. Distichals twice as wide as long, and not in contact laterally. The higher orders of brachials to the last axillary slightly constricted in the middle, and gradually decreasing in width but retaining the same length, so that the upper ones are as long as wide, and even longer in young specimens. Arms rather delicate and short for the size of the species; they are very numerous, there being from six to seven to each division of the ray, or twelve to fourteen to the ray, the bifurcations extending to fully one half the length of the arms, and above the palmars given off from the third plate. Structure of ventral disk and anus unknown. Column rapidly twisting; the two or three proximal joints circular, the others elliptic, increasing in length downward; the long diameter of the joints fully twice the shorter one.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa, and Henderson Co., Ill.

Remarks.—This species is apparently a descendant of *P. sculptus*; its arms, however, are distinct enough for specific separation. It approaches *Eucladocrinus* in the bifurcation of the arms, but the brachials from which the arms are given off to one half the length of the free rays are not formed into rigid tubes, but retain the character of arm plates.

***Platycrinus Saffordi* HALL.**

Plate LXVII. Figs. 1, 2, 3.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 635, Plate 18, Figs. 5 and 6.

1881. W. and SF.; Revision, Part II., p. 74 (Proceed. Acad. Nat. Sci. Phila., p. 248).

A large species. Calyx oblong, unusually large in proportion to the arms. Dorsal cup urn-shaped, the bottom broadly truncated, the sides gradually spreading to the basi-radial suture, and almost cylindrical along the radials. Ornamentation of the plates as in the two preceding species, but generally somewhat coarser upon the basals, while less distinct at the upper portions of the radials.

Basal cup large and very deep, its height almost equal to three fourths the length of the radials; the bottom broadly truncated, almost flat; the lower edge sharp, with an undulated outline. Radials subquadrangular, and in large specimens nearly once and a half as long as wide; the middle portions a little elevated, especially toward the facets, the upper angles slightly inflected, leaving a shallow angular depression at the suture line; the sides of the plates parallel. Facets small, restricted to the extreme upper end of the plates, and occupying but one third of their width. Distichals and the plates of the higher orders to the uppermost axillary moderately long, the first plate of each order narrower than the second, and all free from the costals up. Arms short and of moderate size, given off alternately; biserial from the second plate succeeding the axillaries; there are from four to six arms in each subdivision, or as many as twelve to the ray.

Ventral disk depressed hemispherical, the plates more or less convex, covered with numerous small pustules, and each one crowned with two or three conspicuous nodes. Orals very little larger than the adjoining pieces; the ambulacral plates on the same plane with the interambulacrals. The latter are arranged: 3, 2, 1; the middle one of the first row large and hexangular, that of the anal side a little wider. Anus excentric and directed

laterally. Column observed to a length of 29 cm. without showing cirri. The joints change rapidly from circular to elliptical, and in width from 7 mm. to 17 mm. within 40 mm. from the crown, and from 1 mm. to 3 mm. in length. Their outer margins are angular, and the middle portions covered with a transverse row of ill-defined nodes.

Horizon and Locality. — Upper Burlington limestone and Keokuk group; Indian creek, Montgomery Co., Ind.; Keokuk, Iowa, and throughout Kentucky, Tennessee, Illinois, and Missouri, at the same geological horizons.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — In a paper on "Transition forms in Crinoids" (Proceed. Acad. Nat. Sci. Phila., 1878, p. 244), we made this and the preceding species varieties of *P. sculptus*. They agree so closely in the form of the dorsal cup, and in the style of ornamentation, that it is impossible to separate them unless the arms are preserved, and even these do not differ essentially except in number. We now rank them as full species, but believe that *P. glyptus* and *P. Saffordi* are lineal descendants of *P. sculptus*.

***Platycrinus scobina* M. and W.**

Plate LXVIII. Figs. 14a, b.

1861. MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 129; also Geol. Rep. Illinois, Vol. III., p. 466, Plate 16, Fig. 9.

1881. W. and SP.; Revision, Part II., p. 75 (Proceed. Acad. Nat. Sci. Phila., p. 249).

Syn. *Platycrinus clytis* — HALL, 1861; Prelim. Descr. New Spec. Crin., p. 4; also Boston Journ. Nat. Hist., Vol. VII., p. 286; figured 1872, N. Y. State Mus. Nat. Hist., Bull. 1, Plate 2A, Fig. 4, and Mem. Am. Mus. Nat. Hist., Vol. I., Part I., p. 2, Plate 3, Fig. 6.

A small species. Dorsal cup basin-shaped, more than once and a half as wide as high, the radials slightly convex, especially below the facets, giving to the transverse section of the cup an obscurely pentangular outline, and to the interrarial sutures a shallow angular depression. Surface of cup ornamented with numerous small nodes or coarse granules, rather sharply elevated, closely set, and irregularly arranged, which produce a rasp-like appearance.

Basals closely anchylosed, leaving no groove or mark; they form a rounded basin, which rises to two fifths the height of the dorsal cup; the column facet small, and almost on a level with the truncated lower face. Radials a little broader than long, widening somewhat upwards, and presenting a subquadrangular outline; the superior faces almost straight, their outer ends being but very slightly truncated. Radial facets small, occupying

scarcely one third the width of the plates, and extending but little inward. Costals subtriangular, the sloping upper faces concave, the angle sharp. Distichals nearly as long as wide, not in contact laterally, each one giving off two arms. Arms four to the ray, rather delicate from their origin, composed of cuneate pieces, which interlock from the fourth or fifth piece and become biserial; their joints are long, and all more or less constricted across the middle. Ventral disk moderately high, hemispheric; its plates numerous. The interambulacral pieces of the regular sides consist of three and two plates, so far as observed, of which the middle one of the first row is large; the anal side has five in the first range, followed by numerous very small, convex pieces, forming a large, well defined protuberance, which encloses the anus. Orals and ambulacral plates not visible in the specimens.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks. — Hall's *P. clytis* is a young specimen of *P. scobina* M. and W., and the former name should have priority if the form had been satisfactorily described; but unfortunately the short preliminary notice of it which Hall gave is insufficient for specific identification, and we must in justice to Meek and Worthen accept their name. Hall's more elaborate description, which appeared in 1862, is misleading, for he describes the species as having only three arms to the ray, in which it would be unique among all *Platycrinidae*. Hall's type was imperfect, and the arms, according to the figure, are uniserial throughout, as in all young specimens of *Platycrinus*.

***Platycrinus parvinodus* HALL.**

Plate LXVIII. Figs. 6a, b.

1861. HALL; Descr. New Spec. of Crinoids, p. 17.

1881. W. and SP.; Revision, Part II., p. 73 (Proceed. Acad. Nat. Sci. Phila., p. 247).

A small species. Dorsal cup wider than high, broadly caliculate, slightly obconical at the lower end, the sides evenly convex. Plates extremely thin, marked by irregular lines of sharp, very small nodes, passing from the radial facets to the lower angles of the plates, and from the columnar facet to the upper angles of the basal cup, with a few similar nodes irregularly scattered upon the surface. The nodes in some specimens are only visible with a magnifier. Basi-radial and interradial sutures on a level with the general surface of the plates.

Basal cup somewhat obconical, with a slight truncation at the lower end, surrounded by a small circular ridge; height equal to one half the length of the radials; interbasal sutures obsolete. Radials longer than wide in the adult, a little wider in young specimens; the lower face rounded at the margin; the sides slightly curving inward near the top; the upper face almost straight, sloping very little at the outer ends; the outer face abruptly elevated beneath the facet, forming a prominence or node about equal in size to the costal. Facets very small, directed upwards, occupying rarely more than one fourth the width of the radials, and not entering the body of the plate, or only very slightly. Costals irregularly pentangular, the sloping upper faces concave, the angle sharp. Distichals two, as long as wide, giving off two arms from each side, which remain simple. Arms rather small, composed of moderately long, cuneate pieces, which gradually interlock, and from the radials up are constricted at the middle; the sockets for the attachment of the pinnules projecting. Pinnules not in contact, rather large. Interradial plates erect, five so far as observed; the middle one large, subquadrangular—that of the anal side widest—it is flanked at each side by two small pieces, which together rarely reach the height of the middle one, and both are in sutural contact with the distichals, thus being strictly interbrachial in position. All other parts of the tegmen unknown.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks. — This species resembles *P. scobina* M. and W.; but is readily distinguished by its much smaller and sharper nodes, which are sparingly scattered upon the surface; while those of that species are densely crowded. It is also remarkable for the abrupt elevation beneath the radial facet, which appears almost as if constituting a part of the costals.

Platycrinus geometricus W. and Sp. (nov. spec.).

Plate LXVII. Fig. 10, and Plate LXVIII. Fig. 8.

A small species somewhat resembling *P. scobina*, from which it differs in the greater height of the dorsal cup, in the ornamentation, and in the peculiar form of the arm plates. Dorsal cup bell-shaped, about as high as wide, slightly spreading upwards. Surface of plates covered with knife-like, conspicuous, undulated ridges or rows of sharp, confluent nodes, passing out

from the arm bases to the lower angles of the radials, where they meet with other ridges radiating from the column facet, with which together they form well defined rhombs. Similar ridges proceed horizontally from the radial facets to the sides of the plates, constituting a ring around the upper end of the cup. Each rhomb encloses about twelve prominent, densely arranged nodes, and other nodes fill the triangular spaces between the rhombs. Basiradial and interrarial suture lines not grooved, the interbasal ones obsolete.

Basal cup broadly obconical, its height equal to half the length of the radials; the column facet narrow. Radials slightly spreading, subquadrangular, three fourths as long as wide; the lower face equal to the lateral ones; the limbs at the sides of the facets a little sloping, supporting a very large interrarial plate; the facets extremely small, occupying less than one fourth the width of the plates, and entering but slightly the upper margins. Costals pentangular, as long as wide, sharply angular at the top; the distichals as long, but a little narrower. Arms four to six to the ray, quite delicate, and composed of long, cuneate pieces which gradually interlock. The brachials, from the radials up, provided with well defined sharp projections at both the upper and lower ends; the middle portions deeply constricted, producing a somewhat zigzag appearance; the lines of union rather gaping. Pinnules moderately strong, and not in contact. The ventral disk is covered by the arms in the two specimens examined, with the exception of the interradians of the first row, the middle one of which is proportionally large and covered with nodes similar to those upon the radials, the two at the sides being narrow and without ornamentation. Proximal stem joints circular, with small nodes surrounding their margins.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.
Types in the Museum of Comparative Zoölogy.

***Platycrinus nodo-striatus* W. and Sp. (nov. spec.).**

Plate LXVI. Figs. 5a, b; Plate LXX. Figs. 3, 4a, b, c.

Of medium size. Calyx globular, about as wide as high, rounded at both ends. Width of dorsal cup once and a half to twice its length, the entire surface of the plates densely covered with more or less confluent nodes, arranged in concentric lines around their margins, and traversed by two well defined ridges or rows of nodes passing out from the facets to the lower angles of the plates. The nodes surrounding the column facet more promi-

nent and larger, forming a sort of rim around the stem. Suture lines slightly grooved, except the interbasal ones, which are invisible.

Basal cup moderately deep, its height equal to almost one half the length of the radials; the bottom slightly truncated, and having a circular depression wide enough for the reception of the proximal stem joint. Radials a little wider than long, slightly spreading upwards, the outer ends of the upper face distinctly truncated; the facet semicircular, deep but rather narrow, directed obliquely upwards, slightly notched at the top. Costals small, sometimes not occupying the full width of the facet. Distichals twice as wide as long, free above the costals. Palmars as long as, but narrower than, the distichals. Arms six to eight to the ray, rather long, the three or four proximal plates above the axillary cuneate and uniserial, those beyond gradually passing into biserial. Ventral disk one third shorter than the dorsal cup, sub-pyramidal, the plates convex. Posterior oral larger and more prominent than the others, the latter twice as large as the adjoining covering pieces. Ambulacra almost on a level with the general surface, dividing upon the disk. Interambulacral plates 3 and 2, those of the first row in part interbrachial and almost flat; the middle one hexagonal and longer than wide; the two at the sides scarcely bending outward. The middle plate of the anal side projecting and forming with the plates above, which are quite small and very numerous, a low ridge following the median line. Anus low down, directed almost horizontally. Column facet circular; the stem joints elliptic and twisted, those close to the root nearly three times as wide as the proximal ones.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Types in the collection of Wachsmuth and Springer.

Remarks. — Meek and Worthen have referred this form to *P. tenuibrachiatus*, as their figure 4b on Plate 3, Vol. V. of the Illinois Report evidently represents this species, the ornamentation not being correctly given in the figure. It differs from that species in the more elongate form of the dorsal cup, the much deeper base, and the surface markings. Specimens of this type exhibit much variation in number of arms, nine arms to the ray being sometimes found. Figs. 5a, b, on Plate LXVI., represent a variety from the Lower Burlington, which we cannot distinguish from this species.

Platycrinus peculiaris W. and Sp. (nov. spec.).*Plate LXVIII. Figs. 7a, b.*

Of medium size. Calyx one third higher than wide; the dorsal cup about as wide as high, obconical at the base, cylindrical along the radials; the plates rather thin. The ornamentation of the plates cannot be accurately ascertained in the specimens, but the surface shows traces of obscure ridges passing down diagonally from the radial facets to the lower angles of the radials, and from the column up to the angles of the basal cup, which suggests that the surface was marked in a similar manner as in *P. sculptus*, but perhaps less distinctly. The sutures slightly grooved.

Basal cup basin-shaped, its height equal to one-half the length of the radials, gradually expanding upwards, and slightly beveled around the upper margins; the column facet small, somewhat projecting, and the interbasal suture lines distinct. Radials subquadrangular, nearly as wide as long, the median line sometimes a little elevated, the lower faces very slightly convex; the lateral faces almost parallel, the sloping upper faces wide and forming broad interrarial notches, of which that at the anal side is deeper than the others. Facets extremely small, not occupying more than one fourth the width of the plates, and often considerably less. Costals small, as long as wide, occupying the entire facet. Distichals narrow, almost as long as wide, all in sutural contact with adjoining interrarial plates, and as such constituting a part of the calyx, although having the form of free arm plates. Ventral disk hemispheric, slightly bulging at the anal side, studded with numerous small, nodose pieces, of very nearly equal size. The orals unusually small; the ambulacral pieces on a level with the other disk plates, and of the same size; they are very regularly arranged, and branch upon the disk. The interrarial plates consist of three rows of three each; those of the first row are perfectly flat, and interbrachial in position, the others being nodose and interambulacral; the middle plate of the first row very large, oblong and heptagonal, the two at the sides as long, but very much narrower. Anus excentric, at the top of a small protuberance. Number of arms unknown.

Horizon and Locality. — Lower Burlington limestone; Lake Valley, New Mexico.

Type in the collection of Wachsmuth and Springer.

Remarks. — Resembling *P. parvinodus* in its general structure, but differing in the details. It is readily distinguished by its more elongate form, and having the lower brachials to the top of the distichals always preserved in the specimens by reason of their sutural union with the interrarial plates.

ORNIGRANULUS GROUP.

Basals and radials forming a cup with moderately spreading sides, the radial facets deep and wide; arms short and very heavy throughout; the plates covered with coarse granules or irregular nodes.

***Platycrinus ornigranulus* MCCHESENEY.**

Plate LXVI. Fig. 8, and Plate LXVIII. Figs. 10a, b, c, 11a, b, and 12a, b.

1860. MCCHESENEY; Descr. New Palæoz. Foss., p. 5; and Trans. Chicago Acad. of Sci., p. 3, Plate 5, Fig. 8.

1881. W. and SP.; Revision, Part. II., p. 73 (Proceed Acad. Nat. Sci. Phila., p. 247).

Syn. *Platycrinus nodulosus* HALL, 1853 (not Goldfuss, 1853); Geol. Rep. Iowa, Vol. I., Part II., p. 541.

Calyx of medium size, cup-shaped, moderately spreading; the base but slightly convex, the lower part truncated, and the median portions abruptly depressed for the reception of the column. Surface of plates entirely and closely covered by small granules of irregular size and form, those nearest the margins smaller and more closely arranged, those surrounding the column facet confluent and more or less ill-defined. Similar granules, but smaller, cover the arms, each plate generally having two rows, transversely arranged.

Basals forming a very shallow saucer, of which the bottom is flattened and only the outer margin is visible in a side view; the columnar attachment circular, and marked by distinct radiating striæ; interbasal sutures altogether obsolete; basi-radial and interrarial sutures slightly grooved. Radials about as wide as long, the sides nearly straight, the width of the lower face nearly equal to the length of the lateral ones, the upper faces at the sides of the facets deeply notched. Facets large, occupying nearly one half of the width, and fully two fifths the length of the plates; slightly thickened around the edges; concave; directed outward; the margin of the face crenulated. Costals triangular, short but wide, covering the whole facet; their sloping upper faces concave. Distichals two, the upper one larger than the lower, the latter giving off an arm to the outer side, and

two palmars with two arms to the inner. Arms cylindrical, very stout for the size of the species, and not tapering except at the tips; their plates short. Pinnules strong and closely set, the joints three to four times as long as wide. Structure of the ventral disk unknown.

Horizon and Locality.—Lower Burlington limestone, Burlington, Iowa.

Type destroyed in the great Chicago fire.

Remarks.—The ornamentation of this species is very variable, as shown by the illustrations. In some specimens the entire surface of the plates is covered with small but distinct nodules, in others the nodules are confluent and the surface appears to be coarsely granulated; still others have irregular larger nodes at the median portion of the radials. The basal disk is also flatter in some specimens than in others.

Platycrinus Wortheni HALL.

Plate LXVII. Fig. 9.

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 530, Plate 8, Fig. 4.

1881. W. and Sr.; Revision, Part II., p. 76 (Proceed. Acad. Nat. Sci. Phila., p. 250).

Of medium size. The species is of the type of *P. perasper*, and has a similar ornamentation; but the dorsal cup is more elongate, the nodes upon the plates are less regular, and angular instead of rounded; also the basal disk is proportionally larger, the radials longer and more erect, and each half of the rays has four to five arms instead of three. Dorsal cup cup-shaped, angular along the interradial sutures, and truncate at the base; its whole surface densely covered by prominent granules or subspiniform nodes.

Basal disk concave; sharply pentagonal; the extreme outer margins on a level with the lower edges of the radials; the proximal stem joints circular. Radials as long as wide at the upper end, subquadrangular, the lower faces truncated, the sides very little expanding upwards. Facets wide and deep, surrounded by a projecting rim, the upper margin broadly excavated. Basiradial and interradial sutures slightly grooved, the interbasal sutures obsolete. Costals small, trigonal, wider than long. Distichals short, more than twice as wide as long, and the first, as well as the second, resting within the facets, their inner faces suturally united, as also those of the palmars. The plates of the two succeeding orders of brachials are but slightly smaller than the distichals, and the second plate of each order, as in the case of the distichals, is wider than the first. Arms eight to ten to the ray, rather stout,

very gradually tapering upward, and covered throughout their full length with granules, similar to those upon the dorsal cup, but smaller. Structure of the ventral disk unknown.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

Type in the (Worthen) Illinois State collection.

HEMISPHERICUS GROUP.

Calyx to the arm bases more or less cup-shaped; the sides slightly spreading; the plates covered with distinct nodes. Arms of moderate size.

Platycrinus hemisphericus M. and W.

Plate LXVI. Figs. 1a, b, c, d.

1865. MEEK and WORTHEN; *Proceed. Acad. Nat. Sci. Phila.*, p. 162; also 1866, *Geol. Rep. Illinois*, Vol. III., p. 511, Plate 20, Figs. 2a, b.

1881. W. and Sp.; *Revision*, Part II., p. 72 (*Proceed. Acad. Nat. Sci. Phila.*, p. 246).

Calyx subglobose, rather large in proportion to the arms. Dorsal cup bowl-shaped, twice as wide as high, the bottom excavated for the reception of the column. Basi-radial and interrarial sutures slightly depressed but not grooved. Surface of plates covered with rounded, rather large and prominent nodes. There are generally five rows of such nodes at the base, three or four to each row, which pass out from the column facet to the upper angles of the plate, forming triangles, which are filled by additional nodes. From the radial facets two other rows of nodes proceed to the lower angles of the radials, which are triangularly arranged like those upon the base, and these also enclose a variable number of similar nodes. The sides of the plates are covered with smaller nodes of irregular arrangement.

Basals forming a shallow basin with a slight depression at the lower end; the interbasal sutures indeterminable. Radials subquadrangular, wider than long, moderately expanding in width upwards; the upper faces at the sides of the facets very slightly sloping, except at the anal side where they form a broad and deep notch. Facets horse-shoe shaped, occupying one third the width and height of the plates; directed obliquely upward; the face concave; the upper end deeply notched. Costals very small, trigonal. Distichals free above the first, which is very short; the second a little longer. Palmars, and post-palmars when present, as long as, or longer than, the

distichals. Arms from six to eight to the ray, given off alternately from opposite sides; comparatively thin, and gradually tapering to a sharp point. They are even in the most adult specimens uniserial at the proximal end, being composed of cuneate pieces to the fifth or sixth plate above the bifurcation. The interlocking of the plates evidently took place in this species at a late period in the growth of the individual, for in a specimen in which the crown measures 22 mm., they are still uniserial to the very tips. The joints are rather long, and their surface is covered by small granules, so minute that they are visible only with the help of a magnifier. The edges of apposed faces, from the costals up, are distinctly serrated, and the median portions of the lower brachials are provided with a small transverse ridge. Pinnules closely arranged in the adult, separated in young specimens; the joints very long.

Ventral disk hemispherical, slightly bulging at the sides, the plates tuberculous, large, and nearly of equal size. In some specimens the orals are somewhat larger, and the posterior one sometimes bears two or three nodes instead of one. The covering plates are arranged in rows, and pass out from the orals. Interambulacral pieces apparently four. The anus is located low down at the side, and is very rarely seen, being most generally covered by a *Capula*.

Stem moderately large, circular at the extreme upper end, then turning to elliptical. The joints gradually increase in length, until they are at the lower end of the stem three times as long as at the upper. The outer margin of the upper ones is surrounded by a row of small nodes placed at equal distances, but on approaching the lateral appendages there are but two, which are larger and placed at the long diameter of the joints. Length of the stem not exceeding 25 cm., but generally shorter, terminating in a sharp point. Lateral cirri short and circular.

Horizon and Locality.—Keokuk group. Found in large quantities and excellent preservation at Crawfordsville, Ind.; rare at Keokuk, Iowa.

Type in the Illinois State collection, Springfield.

Platycrinus verrucosus WHITE.

Plate LXVI. Figs. 3a, b, and Plate LXVIII. Figs. 1a, b, c, d.

1862. WHITE; Boston Journ. Nat. Hist., Vol. VII., p. 502.

Of medium size. Calyx below the arms deeply cup-shaped, about as wide as high; the sides almost straight, and the suture lines not grooved. Surface of the cup marked by somewhat scattered, very prominent, wart-like nodes, elevated abruptly. They are irregularly distributed, except upon the basals, where a row of ten large elongate nodes surround the column facet, their sharper ends pointing to the column, the thicker and wider ends directed outward; these are enclosed by an irregular row of somewhat smaller, rounded nodes. Surface of the arms not ornamented.

Basal cup large, saucer-shaped, pentangular in outline, the angles pointing upward; flat at the bottom, the column facet circular, moderately large and but slightly depressed; the interbasal suture lines indeterminable. Radials sometimes a little longer than wide, the lateral faces straight and nearly parallel, the lower faces convex, the upper faces at the sides of the facet short and but slightly sloping. Radial facets less than half the width of the plates, and occupying but a small portion of their length. Costals small, trigonal. Distichals of the same ray in contact laterally; the first very small, the second somewhat larger. Palmars larger than the distichals. Arms four to six to the ray; smooth, rather long, moderately heavy at the proximal end, but tapering slightly upward. They are composed of rather long pieces, which become biserial above the third plate. Pinnules long. Structure of the ventral disk and column unknown.

Horizon and Locality.—Lower Burlington limestone, Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Platycrinus pocilliformis HALL.*Plate LXVIII. Figs. 2a, b.*

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 528, Plate 8, Figs. 2a, b.

1881. W. and SP.; Revision, Part II., p. 74 (Proceed. Acad. Nat. Sci. Phila., p. 248).

A little shorter than the preceding species. Calyx to the top of the radials cup-shaped, wider than high; the height of the basals equal to nearly one third the length of the cup; the sides very slightly expanding to the middle, the upper ends at right angles to the base of the cup; the suture lines not grooved. Surface of plates marked by rather short, rounded nodes, which upon the basals are arranged in double or triple rows, a row of three extending from the column facet to the upper angles. The radials generally have a row of four or five nodes running from the radial facet to the lower angles of the plates, which enclose four or five others, and there are three or four at each side.

Basals forming a flat, pentagonal cup; the column facet small and barely impressed; the interbasal suture lines indistinguishable. Radials a little wider than long, quadrangular, the upper face constituting an almost straight line; facets small, directed obliquely upward, restricted to the upper ends of the plates, and occupying but one third their width. Arms apparently five to the ray, and ornamented with small nodes.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — Differing from *P. verrucosus* in the shorter calyx, in having less prominent, and differently arranged nodes, and in the ornamentation of the arms.

Platycrinus Yandelli O. and SH. (typical form).*Plate LXVI. Figs. 6a, b, c; and Plate LXVIII. Figs. 3a, b, c.*

1852. OWEN and SHUMARD; U. S. Geol. Rep. Wisc., Iowa and Minn., p. 587, Plate 5A, Figs. 6a, b, c.

1881. W. and SP.; Revision Palæocr., Part II., p. 76 (Proceed. Acad. Nat. Sci. Phila., p. 250).

Of medium size. Dorsal cup low cup-shaped, obscurely pentangular from a dorsal view, the interr radial suture lines forming the angles; the sides nearly straight, slightly expanding. The radial facets almost in the same plane with the surface of the plates, and unusually large, occupying fully half the length of the plates and two thirds their width. Surface of basals

and radials covered with comparatively few, irregularly distributed, rather large and prominent nodes, which sometimes almost take the character of spines. The costals, distichals, and lower palmars have from two to three nodes, which are somewhat smaller than those of the calyx, and transversely arranged, while the biserial arm plates have but one, placed near the inner end, forming together with adjoining ones two rows along the back of the arm.

Basals forming a pentagon, with a circular, rather deep concavity, wide enough to admit the two upper stem joints. Interbasal sutures frequently invisible; the basi-radial and interrarial suture lines slightly grooved. Radials hexangular, the upper ends of the plates one third wider than the lower. Facets very large, facing outward, shallow, transversely elliptical; the upper end slightly excavated for the ambulacral passage. Costals large, triangular, occupying the full width of the facet. There are normally five arms to the ray (exceptionally four or six), one division with three arms, the other with two, the former having two distichals to the inner side; arms of moderate size, their lower ends curving slightly downward; the arm joints rather long. Ventral disk from a third to a half higher than the dorsal cup; the outer ends of the ambulacra slightly protruding; the plates highly elevated, their summits crowned by two or three sharp tubercles. Orals large; the posterior one pushed to the anterior far enough to be in a straight line with the two postero-lateral ones. Ambulacral plates large, arranged quite regularly in two rows. Interambulacral plates from four to five, except at the anal side where the middle one of the first row is much larger than the corresponding plate of the other sides, and followed by a great number of small tumid pieces, which form a large, conspicuous, subcentral protuberance containing the anus. The two plates at the sides are twice as long as wide, and longer than the middle one. Column distinctly twisted; the joints slightly angular around the margin; their long diameter equal to twice the shorter one.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

Remarks. — The dorsal cup of this species is less discoid than it appears in specimens with the arms preserved. The arm facets enter deeply upon the plates, and the lower parts of the arms are directed horizontally, often with a downward tendency.

Platycrinus Yandelli, var. **perasper** SHUM.*Plate LXVIII. Figs. 4a, b.*1865. *P. perasper* — SHUMARD; Catal. Palæoz. Foss. of North Amer., p. 389.1881. *P. perasper* — W. and SF.; Revision, Part II., p. 73 (Proceed. Acad. Nat. Sci. Phila., p. 247).Syn. *P. nodobrachiatus* HALL, 1861 (not 1858); Descr. New Spec. of Crin., p. 17.

In the form of the dorsal cup, the proportions of its plates, and the size of the arms, closely resembling *P. Yandelli*, but the nodes covering the surface much more numerous; they are placed close together without being confluent, are very prominent, and cover the dorsal surface of the arms. Those upon the brachials to the last axillary, although smaller, are equally well defined, and are arranged transversely in two rows of from four to five nodes to each row, those upon the biserial arm plates in only one row. The latter are more or less confluent, and form an undulated ridge at the upper edge of the plates, which gives to the transverse sutures a waving outline. This variety generally has six arms to the ray, which are slightly flattened on the back and obscurely grooved along the median line. The stem twists rapidly, and is composed at its proximal end of short elliptic joints.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Platycrinus spinifer W. and SF. (nov. spec.).*Plate LXVI. Fig. 7.*

Closely resembling *P. Yandelli*, but somewhat larger. Dorsal cup saucer-shaped, the basals proportionally large, the radials distinctly curving, their facets projecting outward. Plates thin, covered with large, rather sharp nodes, placed in concentric lines parallel to their margins; there being generally three such lines upon the basals, and two or three upon the radials, the latter arranged so as to form a diagonal line from the facet to each lower angle of the plates. Similar nodes, but somewhat smaller, cover the arms, every plate above the costals having three nodes — the costals four to five — transversely arranged, and occupying the median line of the plates; sometimes, however, in the upper part of the arms, the nodes become confluent and form undulated ridges.

Basals large, slightly convex except the middle part, which is abruptly

depressed for the reception of the column. The interbasal suture lines indeterminate; the basi-radial and interrarial sutures on a level with the plates. Radials rapidly spreading, considerably wider than long; the length of the lateral faces less than the width of the lower one; the limbs incurving, sloping outward and forming wide and deep notches between the plates; their upper ends sharply angular and higher than the upper part of the facet. Facets large, occupying half the width and fully one third the length of the plates; deeply and broadly excavated at the upper end. Costals broadly triangular, rapidly sloping at the middle, their lateral extensions knife-like. First distichal placed obliquely, the second wider and higher than the first, and overlapping it laterally so as to touch the costals. Palmars of the same proportions as the distichals. Arms generally five to the ray, exceptionally six; cylindrical, very heavy and proportionally short. The ventral disk of this species was high, as indicated from fragmentary parts preserved in one of the specimens. The interambulacral regions apparently consisted of five plates, of which the middle one of the first row is very large, and nearly twice as wide as high, the two at the sides as long but narrower; the former having a central spine. Column distinctly elliptic, the edges of the joints studded with numerous small nodes.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Types in the collection of Wachsmuth and Springer.

Remarks. — We were at first inclined to regard this form as a variety of *P. Yandelli*; but the differences in the size of the basal disk and the proportions of the arms, as well as in the form of the dorsal cup, are so remarkable that we concluded eventually to treat it as a full species. It agrees in the form of the dorsal cup with the *Discoideus* group, but in the ornamentation and arm structure it is nearer *P. Yandelli*, *P. verrucosus*, and *P. hemisphericus*, and it doubtless represents a transition form.

***Platycrinus spinifer* var. *elongatus* W. and Sp. (nov. var.).**

Plate LXVII. Fig. 7.

Very closely allied to *P. spinifer*; the dorsal cup deeper, but very little expanding, the basal disk larger and almost flat. The radials rest upon the inner edges of the basals, and are as long as wide; their facets much wider than high, directed obliquely upwards; they extend to less than one third the length of the plates, but occupy half their width. Costals trigonal,

not taking up the full width of the facets. Arms five to six, arranged as in *P. spinifer*, and covered by similar nodes, as also the plates of the dorsal cup. Ventral disk high; the orals large, with a highly elevated central node, which at the top divides into two or three sharp processes. The interambulacral plates flat and erect; the middle one of the first row sharply hexangular, and bearing a small central tubercle.

Horizon and Locality. — Same as last.

Types in the collection of Wachsmuth and Springer.

Remarks. — Most of the specimens of this species agree in the form of the dorsal cup with the *Discoideus* group, but in the ornamentation and arm structure resemble *P. verrucosus*, *P. hemisphericus*, and *P. Yandelli*. There are other specimens, however, in all essential points agreeing with the former, in which the cup is deep and oblong, for which the name *P. spinifer*, var. *elongatus* is proposed.

REGALIS GROUP.

Calyx cup-shaped, the plates indistinctly ornamented; the arms curving outward, and very heavy throughout.

Platycrinus regalis HALL.

Plate LXXII. Figs. 1, 2.

1861. HALL; Descr. of New Spec. of Crinoids, p. 16; figured 1872, New York State Mus. of Nat. Hist., Plate 2A, Fig. 6.
 1881. W. and SP.; Revision, Part II., p. 74 (Proceed. Acad. Nat. Sci. Phila., p. 248).
 Syn. *P. Oweni* MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 129.

A rather large species. Calyx broadly cup-shaped, and but slightly spreading; base large, rounded below; radial facets greatly projecting. Arms at first directed outward, in some specimens spreading horizontally to almost one third their length, the upper ends curving inward until the tips rest upon the ventral disk. Surface of the plates marked by two or three undulated ridges or rows of indistinct nodes, parallel to the upper margins of the plates, and similar ridges, but narrower, surround the edges, giving to the sides of the plates a somewhat beveled appearance.

Basal cup unusually large, pentagonal, its inner edges resting against the lower faces of the radials, sometimes overlapping them; the interbasal sutures distinctly grooved. Radials generally a little longer than wide, slightly expanding, the lower faces convex, the upper faces at the sides of the facets

distinctly sloping, and those toward the anal side considerably widest, giving to the facets of the posterior rays an excentric position. Facets occupying one third the width of the plates, abruptly projecting, the faces slightly convex, the outer margin crenulated, and the median portions provided with an obscure transverse ridge. Costals moderately large, pentangular, rounded on the back, the upper angle obtuse, the upper sloping faces concave, sometimes represented by two plates. Distichals two, as large as the costals, and the upper plate larger than the lower. They give off an arm from the outer side, and two palmars from the inner, which latter support an arm at the one side, and two post-palmars with two arms at the other; frequently, however, there is no further division above the palmars. The number of arms varies from six to nine to the ray, and often in the same specimen; the arms are very stout, and taper but slightly; their plates up to the last bifurcation are constricted in the middle, and the ridges above and below in well preserved specimens are obscurely nodose, those of the biserial upper part slightly convex. Structure of the ventral disk unknown.

Column gradually increasing in width to about 70 mm. from the end, whence it tapers rapidly to a point. Its entire length, as presented in a moderately large specimen (Plate LXXII., Fig. 1), is about two feet from the crown to the filiform ends of the root. It has unusually long twists, and the joints increase continually in length as they grow wider; they are oval, except the two or three proximal ones, which are circular. The lower end of the stem is provided with cirri, the upper of which have a width of 3 mm., the lower ones of 2 mm. at their proximal ends. The latter, which grow very slender, are preserved in the specimen to a length of 40 mm., but were evidently longer.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.
Type in the Museum of Comparative Zoölogy.

Platycrinus eminulus HALL.*Plate LXVIII. Figs. 13a, b, c.*

1861. HALL; Descr. New Spec. of Crinoids, p. 17.

A smaller species than *P. regalis*; the dorsal cup more spreading, and more distinctly pentangular; the base proportionally smaller and flatter, either smooth or marked by obscure concentric bands parallel to the margins of the plates, sometimes separating into distinct lachrymose nodes. Basi-radial and interrarial sutures deeply grooved, and the margins of adjacent plates thickened and highly beveled.

Basals forming a shallow basin, of which the median portions are rather deeply depressed, and only the beveled outer margin is visible from a side view; interbasal sutures rather distinct. Radials forming an angle of about 45° with the bottom of the cup; once and a half — or less — as wide as long, and not quite one half wider at the top than at the bottom. The notches toward the regular interrarial spaces shallow, that at the anal side considerably deeper; the median portions strongly thickened to form the facet, which occupies about one third the width of the upper face. The facet is semi-ovate, deeply notched at the upper end, the surface perfectly flat and directed horizontally. Costals almost as long as wide, wider at the top than at the bottom, the upper angle obtuse. Distichals, palmars, and post-palmars, two to each order; the plates wider than long, gradually decreasing in size; but the upper one of each order larger than the lower, wider and also higher. Arms eight to the ray, given off as in the preceding species; quite heavy, very little tapering, and curving outward. Ventral disk of about the same height as the dorsal cup; composed of a few large plates. The orals sharply tumid; the posterior one resting between the other four, somewhat larger, and provided with a stronger node. The ambulacral plates large, but smaller than the orals, arranged quite regularly in two rows. The interambulacral spaces depressed, formed of three transversely arranged pieces, of which the middle one is as large as the orals, but perfectly flat; that on the anal side larger and curving longitudinally; the opening located in the middle of a small, rounded protuberance, composed of small pieces.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

DISCOIDEUS GROUP.

Dorsal cup low basin-shaped, the radials and arms spreading almost horizontally outward; the arms recurving over the disk.

Platycrinus discoideus O. and SHUM.

Plate III. Fig. 17, and Plate LXVI. Figs. 10a, b, c.

1852. OWEN and SHUMARD; U. S. Geol. Surv. Wisc., Iowa and Minn., p. 588, Plate 5A, Figs. 1a, b.
 1881. W. and SP.; Revision Palæocr., Part II., p. 71 (Proceed. Acad. Nat. Sci. Phila., 245).
 Syn. *P. corrugatus* O. and SHUM., 1852; U. S. Geol. Surv. Iowa, Wisc. and Minn., p. 589, Plate 5A, Figs. 2a-c.
 (not *Pl. discoideus* HALL, 1858; Geol. Rep. Iowa, Vol. I., Part II., p. 535, Plate 8, Figs. 8a, b = *Eucladocrinus pleuroviminus* White).
 Syn. *P. striobrachiatus* HALL, 1861; Descr. New Spec. Crin., p. 4; also Boston Journ. Nat. Hist., p. 287 (figured 1872 in Bull. N. Y. State Mus. Nat. Hist., Plate 2, Figs. 2 and 3 (Type in collection of W. and Sp.). Whitfield; Mem. Am. Mus. Nat. Hist., Vol. I., Part I., p. 4, Plate 3, Figs. 2 to 4.
 Syn. *P. multibrachiatus* MEEK and WORTHEN, 1861; Proc. Acad. Nat. Sci. Phila., p. 134.
 Syn. *P. shumardianus* HALL, 1858; Geol. Rep. Iowa, Vol. I., Part II., p. 532, Plate 8, Fig. 5.
 Syn. *P. pulchellus* S. A. MILLER, 1891; Geol. Rep. Missouri, Bull. 4, p. 11, Plate 1, Fig. 7.

Calyx pyramidal, wider than high; the dorsal cup discoid, almost flat to the middle of the radials, then curving rapidly upwards until the limbs, which rise far above the top of the facets, stand at right angles to the plane of the base. Plates covered by well defined corrugations, which in some specimens are gathered into imbricating folds covering the whole surface; in others arranged in concentric lines conformable to the sides of the plates. Base pentagonal, with a deep concavity in the centre, slightly convex toward the outer margins. Column facet circular; the interbasal sutures invisible. Radials almost as long as wide, allowing for the curvature, and near the summit almost twice as wide as at the base. Radial facets large, lyre-shaped, the vertical diameter equal to one half the length of the plates; the lower rim projecting and on a level with the basals. The surface of the facets concave, and covered with fine radiating striæ without other markings. Basi-radial and interrarial sutures deeply grooved, the edges of the plates strongly beveled. Costals triangular, occupying the full width of the facet. Distichals and palmars twice as wide as high. Arms from six to eight to the ray; one subdivision in the same specimen may have but three arms, the other four and exceptionally five. The arms are rather stout, simple and biserial, and are finely striated longitudinally. Disk almost three times

as high as the dorsal cup. Ambulacra highly elevated, forming broad ridges composed of two series of large spiniform plates alternately arranged, which pass out from between adjoining orals. Orals spine-bearing, and larger than the covering pieces; the posterior one larger than the other four. Inter-radial spaces depressed, composed of five nearly flat pieces, arranged in two rows, all of which are interambulacral. The middle plate of the first row very large; the two at the sides as long as the other, but much narrower. Anus at the summit of a short protuberance, opening out laterally, and placed between the plates of the first and second row, which together with the four smaller orals and the upper plate of the two posterior ambulacra form a ring around the larger orals, giving to the latter a strictly central position. Column twisted; the proximal joint circular, the succeeding ones elliptic; and increasing in length downward.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa, and at the same horizon in New Mexico and Missouri.

Remarks. — This species, although well characterized, is quite variable in details of structure, and has been described under several names. In some specimens, the corrugations upon the plates are more distinct and coarser than in others, and sometimes are obsolete near the facet. The form of the dorsal cup also varies considerably, being in some specimens much deeper than in others, and the outer edges of the basals rise slightly above the plane of the radials. Owen and Shumard's figure of *P. discoideus* represents an extremely flat specimen, and its corrugations are very coarse. In their *P. corrugatus*, on the other hand, the markings are fine, and the dorsal cup considerably deeper, the two representing the extremes of the species. Hall's type of *P. striobrachiatus*, which has the arms preserved, has the ornamentation of *P. corrugatus*, but the form of *P. discoideus*. In Hall's *P. shumardianus* the corrugations are less confluent, and take almost the form of granules or nodes, less marked, however, than indicated by the figure. In *P. multibrachiatus* M. and W., the corrugations do not extend to the median portions of the radials. *P. pulchellus* is a young specimen of the type of *P. striobrachiatus*.

The type of *P. shumardianus* is in the Illinois State collection, Springfield, those of *P. striobrachiatus* and *P. multibrachiatus* in the Museum of Comparative Zoölogy; the fate of those of *P. discoideus* and *P. corrugatus* is unknown.

Platycrinus cavus HALL.*Plate LXVII. Figs. 8a, b.*

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 527, Plate 8, Figs. 1a, b.

1891. W. and SP.; Revision, Part II., p. 71 (Proceed. Acad. Nat. Sci. Phila., p. 245).

Of medium size. Dorsal cup saucer-shaped; the basal disk slightly projecting below the lower margins of the radials; the latter curving gently upwards. The facets face somewhat outward, and have a slight depression around their lower margins. Surface marked by concentric lines of nodes or granules, which are sometimes confluent. There are two or three ranges of these nodes parallel to the margins of the basal disk, and similar ranges of nodes surround the radials, leaving a plane space equal to the granulate portions between the latter and the edges of the facets. Basiradial and interrarial sutures channeled, and the sides of the plates slightly beveled. Ventral disk high, pyramidal; the plates moderately convex.

Basal disk rather large, concave in the middle to the width of the stem; the interbasal suture lines grooved, but the sutures invisible. Width and length of the projecting radials as four to three. Facets projecting, semi-circular; slightly notched at the upper end; the surface concave. Costals subtrigonal, moderately large, occupying the full width of the facets; much wider than high. Distichals rather short; placed obliquely against the costals, and directed outward. The higher orders of brachials are not preserved in the specimen, but portions of the arms indicate that the species had from six to eight arms to the ray, which were comparatively delicate. Ventral disk twice as high as the dorsal cup; the interambulacral spaces depressed, the ambulacra rising abruptly above the general surface of the disk. Orals incompletely visible in the specimen, so that their arrangement could not be ascertained, but the plates are large. Covering pieces alternately arranged in two rows; all equal in size. Interambulacral plates 3 and 2; the two outer ones of the first row curving outward, and the middle one larger than the others. The middle plate of the anal side somewhat the widest and shortest, and its upper margin slightly furrowed by the anus, which is placed low down upon the disk and directed laterally.

Horizon and Locality. — Lower part of Upper Burlington limestone; Burlington, Iowa.

Type in the (Worthen) Illinois State collection at Springfield.

Remarks.—This species is of the type of *P. discoideus*, but the dorsal cup is deeper, the facets shorter, semi-circular instead of lyre-shaped, and the limbs do not extend above the height of the facets. It also departs from that species in the ornamentation, and comes from a higher horizon. The description is made from the type specimen shown in the Iowa Report, Plate 8, Fig. 1a, which is somewhat crushed at the base; figure 1b, on the same plate, is from a different specimen, which may be of another species.

Platycrinus Gorbyi S. A. MILLER.

Plate LXVIII. Fig. 15.

1891. S. A. MILLER; Geological Survey of Missouri, Bull. 4, p. 15, Plate I., Fig. 14.

In the form of the dorsal cup and the proportions of the plates closely resembling *P. cavus*; but the ornamentation is coarser, and the radial facets smaller, more projecting, and their faces flat instead of concave.

Dorsal cup decagonal in a dorsal aspect; the basal disk projecting distinctly below the lower margins of the radials; the sides of the latter expanding rapidly so as to form a flat, spreading cup. The plates moderately strong; their surface covered with two irregular rows of rather large nodes, of which the outer ones are frequently confluent, and form an undulated ridge around the beveled edges of the plates. The basi-radial and inter-radial sutures deeply channeled. Basal disk regularly pentagonal, flat around the margin, with a slight funnel-shaped depression in the middle; the proximal stem joint circular; interbasal sutures obsolete. Radials one third wider than long; the ends of their limbs almost on a level with the upper ends of the facets. The facets semi-ovate, and but slightly notched at the upper end; they occupy about a third of the width of the plates, and not quite one half their length. All other parts of the species unknown.

Horizon and Locality.—Lower Burlington limestone, Burlington, Iowa, and Sedalia, Mo.

Type in the collection of Mr. R. A. Blair of Sedalia.

Platycrinus subspinosus HALL.*Plate LXVI. Figs. 9a, b.*

1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 536, Plate 8, Figs. 9 and 10.

1866. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 173, Plate 15, Fig. 6.

Smaller than *P. discoideus*; its dorsal cup has a similar form, but the surface of the plates is smooth or very obscurely corrugated; the ventral disk shorter, convex instead of pyramidal, and composed of but few large plates; the arms heavier, shorter, and without striæ.

Basal disk rather small, broadly and deeply funnel-shaped, the excavations extending almost to the outer margins. The interbasal sutures very slightly grooved, but the basi-radial and interrarial sutures deep, and the edges of the plates strongly beveled. Radials about once and a half as wide as long, and nearly twice as wide at the upper end as at the lower, rising very gradually to the facets, which project distinctly outward; the limbs curving rapidly upward and slightly inward. The facets, which are not thickened around the edges, are directed horizontally, and their faces are perfectly flat; they are wider than high and rather large, occupying nearly two thirds the width of the plates. Costals very large for the genus, and comparatively long; pentagonal; directed outward and slightly downward, so that the succeeding distichals are sometimes at a lower level in the specimen than either radials or basals; the upper angle quite obtuse. Distichals two; the first quadrangular; the second pentangular; but little smaller than the costals, giving off an arm to the outer side of the ray, and two palmars to the inner side; the latter supporting an arm to the inner side, and two post-palmars to the outer, there being normally four arms to each main division and eight to the ray, exceptionally six or seven. Arms heavy, moderately short, rounded on the back; composed of rather long, slightly convex pieces. They are generally outstretched to about half their length, then curve rapidly inward until their tips rest upon the outer margins of the tegmen. Disk decidedly quinquelobate, higher than the dorsal cup; the ambulacra highly elevated into ridges. Orals very large, subspinosus, occupying one half of the ventral surface; rather regular in their arrangement. Disk ambulacra short, composed of but few tumid pieces. The interambulacral spaces small, sometimes formed of a single row of three plates, of which the middle one is quite large, the outer ones as long but narrower.

The latter curve outward to the costals, and meet the covering pieces. When there are more than three plates, the upper ones are very small. Anus placed between the two posterior orals, the opening directed laterally.

Horizon and Locality.—Lower Burlington limestone; Burlington, Iowa, and Lake Valley, New Mexico.

Type in the (Worthen) Illinois State collection (a rather poor specimen).

Remarks.—In a very fine specimen, evidently of this species, Plate LXVI., Fig. 9a, there is an indistinct node within the five angles of the basal disk, and three others, even more obscure, upon the beveled edges at the lower end of the radials.

***Platycrinus excavatus* HALL.**

Plate LXVI. Fig. 4.

1861. HALL; Descr. New Species Crin., p. 4; also Boston Journ. Nat. Hist., Vol. VII., p. 286 (figured 1872 N. Y. State Mus. Nat. Hist., Bull. I., Plate 2A, Fig. 1).
 1893 WHITFIELD; Mem. Am. Mus. Nat. Hist., Vol. I., Part I., p. 3, Plate III., Fig. 5.
 Syn. *Platycrinus sulcatus* MILLER, 1891; Geol. Surv. Missouri, Bull. 4, p. 16, Plate 2, Fig. 2.

A rather robust species, not above medium size. Dorsal cup discoid, forming a flat basin. Only the extreme outer margin of the basal disk projecting below the margin of the radials, the inner portions deeply depressed so as to embrace the three or four proximal stem joints, which do not, however, touch the sides of the concavity. The radials expand very rapidly, curving but little; their upper faces twice as wide as the lower ones; the facets subcircular, somewhat concave, and directed outward and slightly downward. Interbasal sutures obscure, the basi-radial and interrarial ones profoundly and widely channeled; the sides of the basal disk and radials beveled. Outer margins of radials surrounded by a thickened rim or rugose swelling, and the facets by a slight ridge, producing a rather abrupt depression in the median portions of the plates. Surface of basals smooth. Costals triangular, frequently not occupying the full width of the facet; the distichals then touching the radials, and their sloping upper faces making a right angle. Distichals two; the lower one twice as wide as long; the upper wider than the lower, the upper angle obtuse. Arms four to the ray, very stout and short, slightly tapering at the tips. Structure of the ventral disk unknown, except that the anus was at the end of a tube which extended to the full height of the arms, and was composed of spiniform plates.

Horizon and Locality.—Lower Burlington limestone, Burlington, Iowa.

Original *type* said to be in the White collection at Ann Arbor, Mich., but not certainly identified.

Remarks. — Our description was made from the quite perfect specimen figured on Plate LXVI., Fig. 4, which we have identified as belonging to this species, although much smaller than Hall's type, and the specimen figured by Miller as the type of *P. sulcatus*. The specimen figured by Whitfield as Hall's type is somewhat imperfect in the basal disk; the very large pentapetalous opening in the centre is due to accident, as no *Platycrinus* in its normal condition had an opening in the base for the central canal of any such size or shape as the figure shows. The species is interesting as being the first authentic *Platycrinus* in America in which a long anal tube has been observed. It is plainly shown in our specimen, but is broken off just within the tips of the arms, and does not appear from the view given in our figure.

EUCLADOCRINUS MEEK (emended W. and Sp.).

1871. MEEK; U. S. Geol. Survey of Montana by Hayden, p. 373.
 1878. W. and Sp.; Proceed. Acad. Nat. Sci. Phila., p. 243, and 1881, Revision, Part II., p. 76 (Proceed. Acad. Nat. Sci. Phila., p. 250).
 1890. S. A. MILLER; North Amer. Geol. and Palæont., p. 244.
 Syn. *Platycrinus* (in part) HALL 1858; WHITE 1862.

Construction of the dorsal cup, ventral disk and column, as in *Platycrinus*, but the brachials extended outward and forming large tubular appendages or arm trunks, which pass out from the calyx, and give off the arms alternately from opposite sides. These trunks are extensions of the calyx, composed of a greater or less number of successive orders of brachials, of two plates to each order; they are roofed over by large, rigid, or nearly rigid, covering plates throughout their whole length, forming a good sized tubular passage underneath, which communicates with the inner part of the calyx. There are generally two such trunks to the ray, which are in contact to near the top of the palmars, and support a single arm from every axillary. Some species, however, have but one appendage to the ray, and their arms are given off in clusters of four or more from every second brachial. The arms are of moderate size, biserial and pinnule-bearing, but were apparently short, and the lower ones did not rise to the top of the crown.

Distribution. — Restricted, so far as known, to the upper part of the Burlington and the lower beds of the Keokuk groups of America.

Type of the genus: *Eucladocrinus montanensis* Meek.

Remarks. — This genus bears the same relation to *Platycrinus* that *Steganocrinus* does to *Actinocrinus*. In both groups the rays branch in their free state; but while in *Platycrinus* and *Actinocrinus* the covering plates are movable from the costals up, they are in sutural contact in *Eucladocrinus* and *Steganocrinus* to the end of the appendages, and the latter practically form extensions of the calyx.

In Part II. of the Revision we placed under this genus only those species in which the arm trunks extend to the full height of the crown, and in which the arms are given off singly from opposite sides. This excluded such forms as "*Platycrinus*" *prænuntius* and "*Platycrinus*" *tuberosus*, which have unquestionably the characteristics of *Eucladocrinus*, but less completely developed.

***Eucladocrinus millebrachiatus* W. and Sp.**

Plate LXXIII. Fig. 1, and Plate LXXIV. Figs. 2, 3, 4, 5, 6, 7, 8, 9.

1878. W. and Sp.; *Proceed. Acad. Nat. Sci. Phila.*, p. 245, and 1881, Revision, Part II., p. 77 (*Proceed. Acad. Nat. Sci. Phila.*, p. 251).

A rather large species, resembling *Platycrinus glyptus* in the form of the calyx and style of ornamentation. Dorsal cup bell-shaped, a little higher than wide, the rays extended outward and forming above the distichals ten ponderous tubular appendages, two to the ray, which, curving downward, expose the ventral surface, and give off simple arms to nearly the full height of the crown. Ventral disk very short and flattened on the top. Surface of basals and radials marked by rows of small nodes and rugose ridges, arranged parallel to the margins of the plates, and radiating to their angles.

Basals forming a saucer-shaped dish, equal in height to one third the length of the dorsal cup, truncated at the bottom, the middle portions depressed to the width of the column; the interbasal sutures invisible. Radials longer than wide, very slightly increasing in width upward, a little gibbous in the middle, and swelling toward the facets; the edges of the plates not beveled, and the interrarial suture lines ill-defined. Facets large, semi-circular, facing almost horizontally outward, occupying two thirds the width of the plates and nearly one third their height; the surface slightly pitted in the middle. Costals very short but wide, filling the entire surface of the facets, and abutting against the lower end of the interrarial plates; the distal faces, although the plates are axillary, almost parallel with the proxi-

mal face, having only a small angular projection at the median line. Distichals two, short, four times as wide as high, those of the same ray suturally connected as far as the middle of the second plate, which latter gives off an arm to the outer side of the ray. The succeeding orders of brachials form the dorsal side of the appendages; they are composed of an indefinite number of successive orders of two plates each, of which every second plate is an axillary, thus giving off alternately from the one side an arm, and from the other the next order of brachials. The arm-bearing faces are much the shortest, and slope abruptly downward; the others form a nearly horizontal line, so that the plates of the appendages are transverse but not exactly parallel, as the axillaries are slightly cuneate. The trunks are three to four times thicker than the arms; they decrease but little in size upwards, and terminate in two short arms; the plates are of nearly the same length, about three times as wide as long, rounded on the back, and transversely angular at the outer faces. The length of the arms cannot be accurately ascertained from the specimens, but it appears as if the proximal ones did not rise to the top of the crown; they are biserial, of moderate size, pinnule-bearing, and they decrease slightly in width upwards. The proximal arm plates are rather deeply set into the ray, and while they rest chiefly upon the cuneate axillary, they abut also against the adjoining plates above and below, which are truncated for their reception. In one of the specimens, the arms near the calyx touch five plates, but higher up only four, which is the general rule. The arms are very numerous; in a specimen of medium size we counted twenty-four arms to one branch, but the extreme end is not preserved; and we have reason to believe that they averaged in large specimens at least ten more, which would make about thirty-five to the half ray, or three hundred and fifty to the individual. Beneath each arm, within the appendages, there are two well defined respiratory pores, one piercing the upper edge of the arm facet and lower end of the node-bearing plate above, the other placed at the angle formed by the same plate and two adjoining brachials.

Ventral disk depressed, the orals moderately large, almost central, and the middle part of the plates elevated into rounded, papillate nodes with roughened or wrinkled surfaces; the node of the posterior oral largest. Interambulacral plates flat and without surface markings; they generally consist of four oblong plates, of which the three of the first row are exposed in a side view, only their upper ends, which bend abruptly inward, being

hidden. The covering plates of the ambulacra proceed from the outer sides of the orals to the ends of the appendages; they are suturally connected throughout their full length, and form, together with the plates of the dorsal side, almost rigid tubes. Those of the disk are large, as long as wide, and their surfaces flat; those of the appendages in part are covered with strong nodes. The plate overlying the costals, from which the bifurcation of the ambulacra takes place, is large and nodose. It is succeeded by two rows of transverse plates of irregular size, of which the larger ones are crowned by nodes similar to those upon the orals, but more prominent, and with coarser markings; they are arranged transversely, like the plates bearing them. The larger plates are so disposed that there is one at the base of each arm, and by counting the nodes the number of the arms can be ascertained from them as readily as from the brachials. Between every two nodal plates are two or three smaller ones, which are flat, except for the general curvature. Anus low down, facing laterally. Column large and long, rapidly twisting; the proximal joint circular, the succeeding ones turning abruptly into elongate-elliptic — the long diameter twice the shorter one — and their longitudinal thickness increasing as they recede from the calyx. Each joint is twisted so that the long axes of its reverse faces make a considerable angle with each other; the other rim is beveled to an edge, from which small tooth-like spines proceed outward. The articular ridge well defined, and bordered at the sides by deep fossæ. Axial canal extremely small.

Horizon and Locality.—Transition bed between the Upper Burlington and Keokuk beds; near Burlington and at Pleasant Grove, Iowa. Also in the lower part of the Keokuk *proper* at Niota and Nauvoo, Ill.

Types in the collection of Wachsmuth and Springer.

***Eucladocrinus millebrachiatus* var. *immaturus* W and Sp.**

Plate LXXIII. Figs. 2, 3.

There occur at Burlington in the same bed with *Eucladocrinus millebrachiatus* very much smaller specimens, which are so closely similar to that species that they may represent its younger form; but as no intermediate stages have been discovered, and the gap is rather wide, we deem it advisable to place them at present as a variety under that species. The calyx in these specimens, of which we obtained five examples in excellent preservation, is much shorter than wide, the dorsal cup saucer-shaped, the basal disk

almost flat, and covered with indistinct nodes; while the radials, which are wider than long, are entirely smooth. The calycine appendages, which in one of them are preserved to the distal end, bear but thirteen arms in the largest specimen, which are proportionally rather widely separated. In all other respects, the form in question agrees with *E. millebrachiatus*, to which it bears about the same relation as *Steganoecrinus araneolus* to *S. pentagonus*.

Horizon and Locality. — Burlington and Keokuk Transition bed, near Burlington, Iowa,

Types in the collection of Wachsmuth and Springer.

***Eucladocrinus montanensis* MEEK.**

Plate LXXII. Fig. 5.

1871. MEEK; Hayden's Rep. U. S. Geol. Surv. of Montana, p. 373.

Dorsal cup apparently subovoid, a little higher than wide, widest at the arm bases. Surface of plates smooth. Base basin-shaped, forming nearly one third the height of the dorsal cup. Radials subquadrangular, a little longer than wide, slightly spreading; the lower face a little convex; the upper angles somewhat truncated. Facets moderately deep, their width about equal to the width of the radials. Costals very short, supporting two rather slender appendages, composed of numerous brachials of successive orders, of two plates each, which from the second plate respectively give off the arms. Arms rounded at the dorsal side, biserial and pinnule-bearing. All other parts of the species unknown.

Horizon and Locality. — Subcarboniferous; Montana (the exact locality not being given).

Type in the Smithsonian Institution, No. 7805.

Remarks. — This species probably resembles *Eucladocrinus millebrachiatus* W. and Sp.; but the plates are not ornamented, the appendages seem to have been more slender and erect. It was described from a single very imperfect specimen, in which the base is badly distorted, and only small portions of the calycine appendages are preserved; these, however, show the structural peculiarities of the genus, while the specimen is too imperfect to admit of an accurate specific description.

Eucladocrinus pleuroviminus WHITE.*Plate LXXIII. Fig. 4, Plate LXXIV. Fig. 1.*1862. *Platycrinus pleuroviminus* — WHITE; Proceed. Bost. Soc. Nat. Hist., Vol. IV., p. 17.1878. *Eucladocrinus pleuroviminus* — W. and SP.; Proceed. Acad. Nat. Sci. Phila., p. 244, and 1881, Revision, Part II., p. 77.Syn. *Platycrinus discoideus* HALL; 1858 (not OWEN and SHUM. 1852); Geol. Rep. Iowa, Vol. I., Part II., p. 535, Plate 8, Figs. 8a, b.

A very large species; the calyx sometimes reaching a width of 60 mm. The form of the dorsal cup extremely variable, from discoid to low cup-shaped, and from distinctly decangular in its dorsal aspect to almost circular; its height in some of the specimens scarcely a third of the width, in others equal to one half. Plates of the cup very heavy, and frequently highly ornamented over the whole surface, sometimes only around the margins; while in some cases they are almost devoid of any surface markings whatever. In most of the specimens, however, the surface is covered by irregular wrinkles and rugose ridges parallel to the margins of the plates, and similar ridges pass from the lower edge of the radial facets to the inferior angles of the radials, and from the column to the upper angles of the basals. Other specimens have a broad, roughened single ridge at some distance from the margins of the plates, and deep grooves at either side of it; but in all of them the edges of the plates are distinctly beveled, and the basi-radial and interrarial suture lines channeled. Ventral disk as high as the dorsal cup, and sometimes a little higher, its outer margin rising almost vertically from the upper edges of the radials; the median portions depressed. The species has ten arm trunks given off from the radials almost horizontally, those of the same ray being in sutural contact to the top of the first palmars; they are quite heavy at the proximal end, but taper gradually upward, and curve gently from above the palmars upwards and inwards, supporting from the side of every second plate a simple arm.

Base pentagonal, with a funnel-shaped depression occupying two thirds the diameter of the plate, the margin convex and on a level with the beveled lower end of the radials. The interbasal suture lines more or less deeply grooved, the basi-radial and interrarial ones at the bottom of a broad, shallow channel. Radials moderately spreading, the lower face wider than the lateral ones, the upper end slightly inflected to meet the interambulacral plates, and the angles broadly truncated for their reception; the plates

are thickened around the facets, which project considerably and face almost horizontally. Facets concave, semicircular, the surface crenulated at the margin, their middle portions distinctly granular, the upper end provided with shallow fossæ; the distal faces directed obliquely outward and supporting a large covering plate at each side of the ambulacral passage. Costals depressed pentagonal, five to six times as wide as long, the upper angles obtuse. Distichals as long as the costals at the median line, those of the same ray interlocking laterally with each other and with the palmars above; the axillary rhomboidal, the arm-bearing face directed obliquely to the side, the opposite one horizontally. The palmars have the same form as the distichals, but are a little shorter. Plates of the succeeding orders more cuneate and less regular in their arrangement; the axillaries upwards from the fourth or fifth order decidedly triangular, while the plate below is but little higher at one side than at the other, an arrangement which gives to the upper part of the trunks a waving outline. The arms are set deeply into the trunks, and their two or three proximal plates actually form part of them, being suturally attached to the sides of four or five brachials, which are truncated for their reception. The arms are directed obliquely upwards, are biserial from the second plate, thicker at the proximal ends than at the distal, and they are not very long, the lower ones not rising to the top of the crown. The ventral covering of the appendages has not been observed in this species, being hidden by the arms, but the transverse section shows that it was similar to that of *E. millebrachiatus*.

Ventral disk composed of comparatively few, large, very heavy and convex plates, among which the posterior oral occupies the central part. This is surrounded by eight plates of nearly the same size, viz., the four other orals, the proximal covering pieces of the posterior ambulacra, and two plates, which, together with two others of equal size, form a protuberance enclosing the anal opening. The covering pieces are large, but decrease somewhat in size as they approach the appendages. There are but three interambulacral plates in this species, transversely arranged, of which the middle one, although less convex than the other disk plates, is larger than any of them; it is hexagonal, somewhat elongate, concave at the sides, and it stands erect, being completely visible in a side view.

Column similar to that of *E. millebrachiatus*, but without nodes; the long diameter of the joints proportionally greater, and the twist more rapid than in that species. The joints increase in length rather rapidly near the calyx,

but less so toward the root, and from stem fragments we have seen we judge that the stem must have been quite long.

Horizon and Locality.—Upper Burlington limestone, Burlington and Augusta, Iowa.

Type in the White collection at Ann Arbor, Mich.

Remarks.—This is one of the most magnificent known species of Camerate Crinoids, and one of the two finest specimens of it ever found at Burlington is in the British Museum.

***Eucladocrinus prænuntius* W. and Sp.**

Plate LXXIII. Fig. 5.

1878. *Platycrinus prænuntius*—W. and Sp.; *Proceed. Acad. Nat. Sci. Phila.*, p. 249, Plate 2, Figs. 1 and 2; also *Revision, Part II.*, p. 74.

Of the type of *Eucladocrinus pleuroviminus*, but smaller, the tubular extensions from the calyx much shorter, and giving off less than half the number of arms. Dorsal cup saucer-shaped, its sides sharply angular. The lower part of the radials projecting over the deeply excavated basal disk, and not visible in a side view, or only the points of the angles visible, which are thickened and formed into rounded nodes. The margins of the radials are surrounded by a broad, thickened, rugose rim; while the space around the facets is depressed and without markings. The edges of the plates are profoundly beveled, producing deep channels all along the basi-radial and interradial sutures.

Basal disk pentangular, very deeply funnel-shaped below; the sides slightly concave; suture lines invisible. Radials rapidly spreading, twice as wide as long, moderately curving; the truncated upper faces but little sloping toward the regular interradial spaces, rather deeply at the anal side. Facet projecting, facing outward, semicircular, concave, very slightly notched at the upper end; the extreme outer margins striated. Costals wedge-shaped, not extending to the full depth of the facet. Distichals two, both quadrangular; the second narrower on top than at the bottom, its lateral outer face giving off an arm to the side, the lateral inner face suturally united with that of its fellow of the adjoining division. The horizontal upper face supports four or five successive orders of brachials, each one consisting of two rather large pieces, and the upper one irregularly axillary; one of the sides sloping and giving off an arm, the upper face the next order of brachials.

Arms from six to seven to each main division, or twelve to fourteen to the ray; they stretch outward to the length of the palmars, and then bend upward and inward, being rounded on the back, flattened at the sides, and biserial from the second joint.

Ventral disk fully twice as high as the dorsal cup, rather bulging; the plates large, heavy, and highly convex. Orals in contact laterally; the posterior one central in position and larger than the others, which are oblong and pushed to the anterior side. The fixed covering plates of the ambulacra extend out from the orals beyond the limits of the calyx to about one half the length of the arms, and form together with the different orders of brachials large, tapering, tubular trunks, from which the arms are given off alternately at the sides. Interambulacral plates: 3, 2, 1, all large, but especially the middle one of the first row. At the anal side the middle plate is still larger, and is followed by nine or ten small plates, which take the place of the second row of plates at the other sides, and form a small protuberance enclosing the anus. Above these plates there are two larger ones, which, together with the smaller orals, form a ring around the posterior one. Anal opening directed laterally. Stem elliptical, rapidly twisting, its long diameter nearly three times the shorter one; the joints slightly increasing in width, and their proximal and distal faces provided with a well defined ridge.

Horizon and Locality. — Lower part of the Upper Burlington limestone, Burlington, Iowa, and several places in Missouri.

Types in the collection of Wachsmuth and Springer.

Remarks. — This and the next species have the characters of the genus less pronounced than in the typical forms, and they represent transition forms in different degrees from *Platycrinus*.

Eucladocrinus tuberosus (HALL).*Plate LXXII. Figs. 3, 4 a, b, c.*

1858. *Platycrinus tuberosus*—HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 534, Plate 8, Figs. 7a, b.
 1881. *Platycrinus tuberosus*—W. and SP.; Revision, Part II., p. 76 (Proc. Acad. Nat. Sci. Phil., p. 250).
 Syn. *Platycrinus occidentalis* S. A. MILLER, 1891; Geol. Surv. Missouri, Bull. 4, p. 10, Plate 1, Figs. 5, 6.

Calyx wider than high, hemispheric to subpyramidal, slightly pentangular in outline. Dorsal cup discoid and very short, resting on the projecting margins of the radial facets; the lower edges of the facets directed slightly downward, the limbs bending upward at a right angle. Ventral disk somewhat bulging at the posterior side, and portions of the interambulacral plates visible from a dorsal aspect. Plates thin, without ornamentation, and very little elevated; the sutures slightly grooved. This species, in the form of its brachial trunks, of which there is but one to the ray, and in the arrangement of its arms, which are extremely short and given off in clusters from the sides of the trunks, resembles certain species of *Onychocrinus*.

Basal disk proportionally small, with a small depression in the middle for the proximal column joint. Interbasal sutures obsolete. Radials subhexagonal, lying horizontally to near the facets, where they are twice as wide as at the bottom. The facets occupy less than half the width of the plates; they are semi-elliptical, greatly projecting, directed more or less obliquely downward; they are deeper excavated in the middle, and the margin is obscurely striated. Calycine appendages heavy but short, their transverse section oblong. They are directed obliquely downward to their full length, and are composed of five successive orders of brachials, which give off arms from the outer sides. The different orders, except the costals, consist of two plates each, and are roofed by two series of rigid, very large covering pieces. Costals extremely large, reaching a length of 6 to 7 mm.; they are rounded on the back, the sides abruptly curving inward, and the distal faces, although axillary, almost straight. Distichals 2×2 , a little wider than long and quadrangular; the second pentangular and irregularly axillary. The latter plates give off $2 \times 2 \times 2$ palmars, of which the outer ones support a cluster of arms; while the inner ones take part in the calycine appendages. The lower plates of the outer series are trigonal, and rest upon the sloping upper faces of the distichals and against the sloping lower faces of the inner palmars.

in such a manner, that the direction of the arms is at right angles to the trunks. The second palmars of the inner sides support two orders of post-palmars, the lower one giving off one arm, the upper two. One of the latter arms branches again in its biserial stage so that there are four arms to each cluster. Similar sets of arms are given off from the fourth order of brachials at both sides of the trunks, and also from the distal end.

The plates of the ventral disk are comparatively large and rather prominent; the posterior oral more elevated than any of the rest, and slightly excentric, leaning to the posterior-side; the four others somewhat smaller; all sharply angular and sometimes spiniferous at their summits. The covering pieces of the disk are quite regularly arranged in two rows. Interambulacral plates: 3, 2, 1; the middle one of the first range almost as large as the posterior oral, and the corresponding plate of the anal side even larger. Column rather small for the species, the long diameter of the joints not more than once and a half that of the shorter one; the proximal joint circular, and those succeeding it increasing moderately in length.

Horizon and Locality. — Upper Burlington limestone, Burlington, Iowa, and Sedalia, Mo.

Type in the (Worthen) Illinois State collection, Springfield.

Remarks. — This species departs in its arm structure from all other known Platyocrinoids, and also is readily identified by the form of the dorsal cup. There is no other species known from the Burlington limestone in which the arm facets are directed downward, and in which the calyx rests upon the projecting edges of the radial facets; nor any in which the basal disk is so small proportionally as in this species. It is extremely rare, and was always recognized with ease by the Burlington collectors; but one specimen has ever been found showing the structure of the arms, and that is the crushed specimen in our own collection, which we have figured.

MARSUPIOCRINUS PHILL.

(Not *Marsupicrinites* BLAINVILLE = *Marsupites* MANT., nor *Marsupiocrinites* HALL = *Lyriocrinus*).

1839. PHILLIPS apud MURCHISON; Silur. System, p. 672.
 1842. AUSTIN; Ann. and Mag. Nat. Hist., Vol. X., p. 109.
 1857. PICTET; Traité de Paléont., Vol. IV., p. 332.
 1860. DUJARDIN and HUPÉ; Hist. naturelle des Zoophytes, p. 149.
 1878. ANGELIN; Icon. Crinoid. Suec., p. 2.
 1879. ZITTEL; Handb. der Paläont., Vol. I., p. 365.
 1881. W. and SP.; Revision, Part II., p. 62 (Proceed. Acad. Nat. Sci. Phila. p. 236).
 1890. S. A. MILLER; North Amer. Geol. and Paläont., p. 260.
 Syn. *Platycrinus* (in part) — F. ROEMER, 1860; Silur. Fauna West. Tenn., p. 35.
 Syn. *Cupellæcrinus* — TROOST; 1850, List Crin. Tenn., p. 61; described by Shum. 1866; Cat. Palæoz. Fossils (Trans. St. Louis Acad. Sci., Vol. II., p. 361).

Closely related to *Platycrinus*, but the lower brachials and the first plate of the interrarial series entering rather more into the dorsal cup; the radial facets, instead of being excavated, are nearly straight; the column circular instead of elliptic; and the axial canal very much larger and pentagonal.

Basals arranged as in *Platycrinus*, and similarly anchylosed. Radials large, hexagonal in outline; the upper face supports not only the costals but also the distichals; it is straight, or slightly indented for the reception of each plate. Costals one, very small and trigonal. Distichals one when there is another bifurcation above; they are small, resting with their lower faces upon the radials, with one of their lateral faces against a large interbrachial plate, and at the opposite side against the adjoining distichal of the same ray. Arms from two to four to the ray, rather stout and biserial; the pinnules large. Ventral disk hemispheric; the orals rather small, pushed anteriorly, and quite asymmetrically arranged. The ambulacral plates consist of regular rows of covering pieces, which branch upon the disk, and are separated from those of adjoining rays by rather large interambulacral plates, and the branches from one another by one or two interaxillaries. Column of uniform size throughout, and, so far as observed, without cirri, except perhaps at the extreme end. The joints circular, each pair of nodal joints enclosing an internodal; the axial canal moderately large and pentagonal.

Distribution. — The genus occurs in Europe as well as America, and is restricted to the upper Silurian.

Type of the genus: *Marsupiocrinus calatus* Phill.

Remarks. — Among his list of the Crinoidea of Tennessee, Troost gives under *Cupellæcrinus* the following species: *Cupellæcrinus Buchi*, *C. corrugatus*,

C. inflatus, *C. lævis*, *C. magnificus*, *C. pentagonalis*, *C. rosæformis*, *C. stellatus*, and *C. striatus*, — all from Decatur Co., Western Tennessee — which in all probability are mere varieties of *Marsupiocrinus tennesseensis* (Roemer). A figure of the ventral side of *M. depressus* Ang., from the Upper Silurian of Gotland, Sweden, is given on Plate III., Fig. 23.

***Marsupiocrinus tennesseensis* (ROEMER).**

Plate LXXV. Figs. 16a, b.

1860. *Platycrinus tennesseensis* — ROEMER; Silur. Fauna West. Tenn., p. 35, Plate 3, Figs. 4a, b, c, d, e, f.
 1881. *Marsupiocrinus tennesseensis* — W. and Sr.; Revision., Part II., p. 65 (Proceed. Acad. Nat. Sci. Phila., p. 239).

A rather large species. Calyx greatly depressed, its width about twice its height, the latter equally divided between cup and tegmen. Dorsal cup saucer-shaped, the base flat, the sides slightly convex, rapidly spreading. Plates moderately thin and flat, the ornamentation somewhat variable. In the majority of specimens the surface of the plates densely covered with somewhat irregular, very fine, closely arranged, longitudinal and transverse striæ; the longitudinal ones running in almost parallel lines from the upper edges of the radials to the foot of the basals; the transverse ones, which are restricted to the lateral margins of the radials, traverse the sutures, and meet the longitudinal ones at an angle; the successive angles, as they follow the plates, forming an oblique line from the top of the radials to their lower angles. In other specimens the striæ are broken up into rows of small nodes, some of which are round, but most of them elongate, giving to the surface a peculiar rugose appearance. Sutures not grooved, and often difficult to see.

Basals spreading horizontally, forming a flat, sharply pentangular disk; the column facet surrounded by a small, circular ridge, and the space within slightly excavated; the axial canal rather large and pentagonal. Radials hexagonal; greatest width to length as seven to four, rapidly spreading to two thirds their height, the upper faces almost straight, being but very slightly indented for the reception of the costals; the sloping upper faces forming a deep notch with corresponding faces of adjoining plates. Costals extremely small even for the genus, trigonal, a little wider than long. Distichals two, quite unlike in form and size; the first rather large and sub-lunate, one of its sides abutting against the costals and meeting above with

its fellow of the same ray, the opposite side against the large interrarial plate, the lower face resting upon the radials. The second distichal trigonal, very small, not larger than the costals, the two of the same ray together forming a triangle, from the sloping sides of which the arms are given off, the lower arm plates resting partly upon the distichals. Arms two to the ray, divergent, rapidly tapering at the base, and rather slender above; they are biserial from their origin, and the proximal row of arm plates takes part in the calyx. First plate of the interrarial series very large, its lower portion constituting a part of the dorsal cup, the upper part entering into the ventral disk; it bends abruptly inward at two thirds its height, forming a sharp edge along the margin. The lower end of the plate deeply wedged in between the radials, the middle portion resting against the sides of the distichals, the inflected upper end against the covering plates of the ambulacra. This plate at the four regular sides is followed by two rows of interambulacral plates, generally arranged three and two, of which the upper row abuts against the orals. The anal side has from ten to twelve plates of irregular arrangement. Ventral disk depressed hemispheric, the plates tumid, with a small tubercle in the middle. Orals excentric and asymmetrical, the posterior one wider than long, but not larger than the others. Ambulacral plates much smaller than the surrounding plates; the primary ambulacra roofed by three series of plates, the two outer ones consisting of short, transverse pieces, separated by a few elongate plates. The covering pieces of the secondary ambulacra much smaller, and separated by one or two large interaxillary pieces; they are composed of two rows of regularly alternating plates. Anus almost central. Column round, so far as observed; the axial canal pentagonal.

Horizon and Locality. — Niagara group; Decatur and Wayne Cos., Tenn.
Types in the Mineralogical Museum at Breslau, Germany.

Marsupiocrinus striatus W. and Sp. (nov. spec.).

Plate LXXV. Figs. 17, 18.

A little larger than the preceding species, sometimes attaining a width of 6 cm. Calyx twice as wide as high, height of the dorsal cup about equal to that of the disk. Dorsal cup truncated to near the middle of the radials, then abruptly spreading upwards, the upper end slightly curving inward. Plates densely covered by fine striæ passing from the radial facets out to the

interradial and basi-radial sutures, and from the latter to the column. Suture lines faintly grooved, except the interbasal ones, which are obsolete. Ventral disk low hemispherical, the plates convex.

Basal disk a little concave, large, decagonal in outline, the faces meeting the radials being more or less distinctly angular. Column facet small, circular, slightly excavated, and surrounded by a faint ridge; the axial canal large and obscurely pentagonal. Radials at their widest place twice as wide as long. Costals extremely small. Distichals large, their outer lateral faces longer than those meeting the costals, their lower faces resting upon the radials. Interradial plate large, placed vertically; the extreme upper end slightly incurving; its lower faces rest between two of the radials, the lateral ones between the second costals, and the three upper support three interambulacra, which are followed by two others in the next row, and these by the orals. Orals quite asymmetrical and small. Ambulacra exposed at the disk, the covering pieces very regularly arranged; composed of rather short, transverse pieces alternately disposed.

Horizon and Locality. — Niagara group; Decatur Co., West. Tennessee.

Types in the collection of Wachsmuth and Springer.

Remarks. — This species differs from *M. tenneseensis* in the very much larger basal disk, which in this species is generally decagonal. The differences in the ventral disk are also quite marked, the ambulacral plates especially being much larger.

***Marsupiocrinus tentaculatus** (HALL).**

Plate LXXV. Figs. 19a, b.

1858. *Platycrinus tentaculatus* — HALL; Palæont. N. York, Vol. III., p. 116, Plate 5, Figs. 1-4.

1881. *Marsupiocrinus tentaculatus* — W. and Sp.; Revision, Part II., p. 65 (Proceed. Acad. Nat. Sci. Phila., p. 239).

A much smaller species than the preceding one, and having twice as many arms. Dorsal cup short, bowl-shaped, slightly lobed at the top. Surface of plates ornamented by radiating ridges, of which seven or eight proceed from the lower edge of the costals to the basi-radial and interradian sutures, and to the basals, where they end in a circular rim surrounding the column facet.

* The specific name has reference to the large pinnules, which by some of the earlier writers were called tentacles.

Basals short, the sutures visible. Radials not quite as wide as long, hexangular; the upper face for the reception of the costals and distichals a little concave; the sloping upper faces forming a deep notch for the reception of a large interbrachial plate. Costals moderately large for the genus, trigonal, wider than high. Distichals a little larger than the costals; pentagonal and axillary. They rest with their lower faces upon the radials, and with one of their lateral ones against each other, with the opposite one against a large interbrachial, which rises to the top of the first arm plate, incorporating this with the calyx. Arms four to the ray; the five or six proximal arm plates wedge-form, and arranged in a single series; the succeeding ones gradually changing from cuneate to pentangular, and disposed in two rows; the surface of the plates somewhat convex and thickened in the direction of the pinnules. Pinnules heavy, composed of long joints, thickened at the extremities, and slightly constricted along the middle. The proximal pinnule of the two inner arms of the ray is given off from the inner side, that of the two outer arms from the outer side of the ray. Structure of ventral disk unknown.

Horizon and Locality. — Lower Helderberg group; Schoharie, New York.

(?) **Marsupiocrinus præmaturus** (HALL and WHITEF.).

Plate LXXII. Figs. 11a, b.

1875. *Platycrinus præmaturus* — HALL and WHITEFIELD: Geol. Surv. Ohio, Vol. II., p. 124, Plate 6, Figs. 3 to 6.

1885. *Marsupiocrinus præmaturus* — W. and SP.; Revision, Part III., p. 115 (Proceed. Acad. Nat. Sci. Phila., p. 337).

Of medium size. Dorsal cup not as high as wide, strongly quinquelobate in a dorsal aspect, owing to the thickened, tumid character of the radials, which form the widest part of the calyx; the sides of the cup rapidly contracting to both ends. Plates heavy and strongly convex; the surface smooth.

Basals moderately large, constituting only a small proportion of the height of the dorsal cup; their centres tumid, and projecting downward in the form of three strong, rounded nodes; the inner portion of the plates, which forms the columnar attachment, deeply concave. The interbasal sutures distinctly grooved. Radials large, more than once and a half as wide as long, the facet for the reception of the costals and distichals somewhat indented,

the outer ends to the sides of the facets slightly truncated by the first inter-radial plate, which is strictly interbrachial, rising only to the top of the first distichals. Costals small, as long as wide, trigonal, the sides convex; they occupy a third of the radial facets, the other two thirds being occupied by the distichals. Distichals two; the first a little larger than the costals, those of the same ray meeting above the latter. Second distichals sub-quadrangular, separated from the first by a deep groove; their outer edges distinctly excavated at the upper end, forming a well defined, semicircular facet for the reception of the arms, which face nearly horizontal. Second distichals separated interr radially by two very small interbrachial plates. Arms two to the ray; their structure and that of the ventral disk unknown.

Horizon and Locality. — Niagara group; near Greenville, Darke Co., and at Cedarville, Greene Co., Ohio.

Type in the collection of Rev. H. Hertzner of Berea, Ohio.

Remarks. — The description and figure were made by Hall from a gutta percha impression of a natural mould in the rock. The specimen figured on Plate LXXV., Fig. 14, may represent a *Marsupiocrinus*, but is more probably, we think, a *Culicocrinus*. It was found in the Niagara at Maquoketa, Iowa.

CORDYLOCRINUS ANGL.

1878. ANGELIN; Iconogr. Crinoideorum Sueciæ, p. 3.

1879. ZITTEL; Handb. der Palæontologie, Vol. I., p. 365.

1881. W. and SP.; Revision, Part II., p. 60 (Proceed. Acad. Nat. Sci. Phila., p. 234).

Syn. *Platycrinus* (in part) — PHILLIPS; Murchison's Siluria, 2d ed., Plate 14, Fig. 9.

Angelin defines this genus as follows: "Basalia tria, connata. Radialia primaria permaxima, cetera magnitudine multoties superantia; secundaria et tertiaria transversa. Interradialia in tribus verticillis. Brachia quinque bidigitata, pinnulæ longissimæ." He places the genus under the Platycrinidæ, and refers to it a single species from Gotland, of which he gives a figure. This species has close affinities with the three American species which Hall (Palæontology New York, Vol. II., pp. 113 to 116) described as *Platycrinus plumosus*, *P. parvus*, and *P. ramulosus*. The latter undoubtedly are generically identical with a small form from the Wenlock group of Dudley, known under the name of *Platycrinus reticularis* Phill., and with two other undescribed species which also occur in the neighborhood of Dudley: one with four arms to the ray, the other

somewhat larger, with only two arms like "*Platycrinus*" *reticarius*, but these beautifully sculptured. All these species, including *Cordylocrinus comtus*, agree in the basals and radials with *Platycrinus*, but have two costals instead of one, and their arms are uniserial as in the young *Platycrinus*, their pinnules large and not in contact laterally. The only point of doubt, and upon which possibly a generic separation from the Gotland form might be justified, is that the American and Dudley specimens have whorls of cirri from all their nodal joints, which are not indicated in the Swedish *Cordylocrinus comtus*. However, cirri may have been represented also in that species, and until their absence is satisfactorily proved, we must refer all the above forms to that genus. The interradial plates, which Angelin described as distributed in three series, in all those species form a part of the disk, only the lower one resting between the brachials. Hall describes a "proboscis" in "*Platycrinus*" *plumosus*, which is imperfectly shown in the specimen, and it is possible that the other species have a similar structure. We propose the following generic diagnosis: —

Basals and radials as in *Platycrinus*. Costals two, narrow, attached to a small facet. Arms from two to four to the ray. When four, the last bifurcation takes place from the sixth, or as high as the ninth distichal. The arms are long and uniserial; composed either of wedge-form plates alternately arranged, or of quadrangular, transverse pieces. Pinnules stout and long, not in contact. The first interradial plates resting against the costals. Column round, with numerous internodal joints, and cirrus-bearing. The cirri very long, directed upward, the upper ones rising to almost half the height of the crown, and arranged in whorls of three to four to the arm joint.

Distribution. — This genus is restricted to the Wenlock group in England and Sweden, and to the Upper Helderberg in America.

Type of the genus: *Cordylocrinus comtus* Angl.

Cordylocrinus plumosus (HALL).*Plate LXXV. Fig. 20.*

1859. *Platycrinus plumosus* — HALL; Palæont. New York, Vol. III., p. 113, Plate 4, Figs. 1 to 5.
 1881. *Cordylocrinus plumosus* — W. and SP.; Revision, Part II., p. 60 (Proceed. Acad. Nat. Sci. Phila., p. 234).
 Syn. *Platycrinus parvus* — HALL; Palæont. New York, Vol. III., p. 114, Plate 4, Figs. 6 to 9.
 Syn. *Cordylocrinus parvus* — W. and SP.; Revision, Part II., p. 60.

A small species. Dorsal cup subpentangular, expanding to the arm bases; surface of plates finely granulated. Basals very thin, wider than long, the column facet small. Radials excavated for the reception of the costals. The three radials meeting an interbasal suture distinctly angular at the lower end, the two others nearly straight. The upper faces of those adjoining the anal side forming a deep notch, occupied by a large pentangular plate, which is succeeded by a smaller plate forming the base of a proboscidiiform tube (Hall, Plate 4, Fig. 3). Costals two. Arms two to the ray, composed of transverse, slightly wedge-form pieces, giving off large pinnules, which are not in contact laterally. Column composed of nodal and internodal joints, the latter rapidly increasing in number, the nodal joints giving off whorls of cirri, one to each side, interradially arranged. The cirri are formed of short pieces; they are filiform and directed upwards, often so long that the tips of the proximal ones pass up to the top of the arms.

Horizon and Locality. — Lower Helderberg group; Schoharie, Herkimer Co., N. Y.

Remarks. — We have not examined Hall's types, but doubt if they show much more of the structure. The form which Hall described as *Platycrinus parvus* is in our opinion a younger form of *Cordylocrinus plumosus*.

(?) Cordylocrinus ramulosus (HALL).*

1858. *Platycrinus ramulosus* — HALL; Palæont. New York, Vol. III., p. 115, Plate 4, Figs. 10 to 13.
 1881. *Cordylocrinus ramulosus* — W. and SP.; Revision, Part II., p. 60 (Proceed. Acad. Nat. Sci. Phila., p. 234).

Dorsal cup small. Basals wider than long. Radials comparatively large, wider than long, very prominent below the facets, and contracted toward the upper lateral angles. Costals two, very small. Arms bifurcating from

* This species may belong to a very different group. It was apparently described from very imperfect specimens, and not having seen the types, we give Hall's description with our terminology.

the second costals, and again from the tenth distichal. Arm joints wider than long, rounded on the back, and with strong pinnules composed of joints a little longer than wide. Column round, rather large, the joints growing thicker downward. Cirri have not been observed.

Horizon and Locality. — Upper Helderberg group; Schoharie, Herkimer Co., N. Y.

COCCOCRINUS MÜLLER.

- 1855. JOH. MÜLLER; Verh. Naturhist. Verein Rheinlande, Vol. XII., p. 20.
 - 1857. PICTET; Traité de Paléont., Vol. IV., p. 310, Plate 100, Fig. 3.
 - 1860. F. ROEMER; Foss. Fauna West. Tennessee, p. 51.
 - 1862. DUJARDIN and HUPÉ; Hist. Natur. des Zoophytes, p. 107.
 - 1879. ZITTEL; Handb. der Paläont., Vol. I., p. 347.
 - 1881. W. and SP., Revision, Part II., p. 58 (Proceed. Acad. Nat. Sci. Phila., p. 232).
 - 1844. P. HERB. CARPENTER; Challenger Rep. of the Stalked Crinoids, pp. 160 to 163.
 - 1885. W. and SP.; Revision, Part III., p. 114 (Proceed. Acad. Nat. Sci. Phila., p. 336).
 - 1887. W. and SP.; Proceed. Acad. Nat. Sci. Phila., p. 22.
 - 1889. NEUMAYR; Stämme des Thierreiches, p. 470.
 - 1890. S. A. MILLER; North Amer. Geol. and Palæont., p. 232.
- Syn. *Platycrinus* (in part) ROEMER; Rhein. Uebergangsgeb., p. 63, Plate 3, Fig. 3.

Coccocrinus is the simplest possible form of the Camerata, the calyx consisting only of three basals, five radials, two costals, five small interbrachials and five orals. As in *Platycrinus*, two of the basals are larger and equal, and the third, which is but half the size of the others, has the same orientation as in that genus. The radials are large, as in all Platycrinidæ, and excavated at the upper end to form a facet for the reception of the costals, which consist of two short, transverse plates (not of one as heretofore supposed). The upper costal is axillary, and supports two arms, which apparently were delicate. The interbrachials rest at all sides upon the truncated upper angles of the radials, and against both costals. The ventral disk is covered entirely by five large orals which slightly touch the radials; they meet in the centre, but are parted on approaching the arm bases, where they leave narrow slits, at the bottom of which small portions of the disk ambulacra make their appearance; while they are at the upper end altogether subtegmenal. The lower margin of the posterior oral, and the upper of the interbrachial plate below, are deeply excavated, and form a large, circular anal opening. Column round.

Distribution. — Two species have been described, one from the Niagara group of Western Tennessee, the other from the Middle Devonian of the Eifel, Germany.

Type of the genus: Coccocrinus rosaceus (Roemer).

Remarks.—*Coccocrinus* has close affinities with *Culicocrinus* Müller, closer even than has been generally supposed. The former was described by Müller as having only one costal, while he recognized two in the latter, and made this the principal distinction between the two genera. Specimens in our collection show conclusively that not only *C. bacca*, but also *C. rosaceus*, has two costals. The only difference in the calyx upon which a generic separation might be upheld, is that in *Culicocrinus* the disk ambulacra are completely subtegmenal, while those of *Coccocrinus* are partly exposed. The disk ambulacra, which are indicated in our specimen of *C. rosaceus*, are very narrow, and composed of minute alternating pieces, but too small to be satisfactorily represented in our figure 14 on Plate III.

***Coccocrinus bacca* ROEMER.**

Plate LXXV. Fig. 15.

1860. F. ROEMER; *Silur. Fauna des Westl. Tenn.*, p. 51, Plate 4, Figs. 5a, b, c.

1881. W. and SP.; *Revision*, Part II., p. 60 (*Proceed. Acad. Nat. Sci. Phila.*, p. 234).

A small species. Dorsal cup bowl-shaped, wider than high, subpentagonal from a basal aspect, and somewhat asymmetrical in its general form. Plates smooth; the suture lines not grooved and frequently invisible.

Basals large, forming a low, rounded, pentagonal basin, provided with a small, circular facet for the reception of the column. Radials a little wider than long, the sides nearly parallel, the median portions slightly curved longitudinally and projecting outward. Three of the radials of similar form and symmetrical, the two posterior ones of irregular outline: the limbs toward the anal side rising considerably above the level of those of the opposite side; radial facets occupying two thirds the width of the plates. Costals two, very short; the upper one axillary with obtuse upper angle. The interbrachial pieces as large as the two costals together; their lower ends resting within a small notch formed by the radials, the sides against both costals, and against the ambulacra, the truncated upper face against the orals. Four of the plates are equal and stand at the same level, their upper ends inflected; the posterior one is erect and elevated above the others. Anus excentric, at the top of the posterior interbrachial, which at its upper end bends longitudinally inward so that its sides meet and form a small tube. The orals unknown.

Horizon and Locality. — Niagara group; Perry Co., Tenn.

Types in the Mineralogical Museum at Breslau, Germany.

Remarks. — Roemer's figures are misleading. The calyx is not symmetrical, as he represented it, and the interbrachial pieces bend but slightly inward, even at the four regular sides. Neither do we find the small plates at their sides, nor the linear ambulacral slits; the spaces between the upper ends of the interbrachial plates are occupied by several small pieces, which are probably covering plates of the ambulacra. He also fails to represent the costals; they are plainly seen in two of the four specimens in our collection occupying the part which in Roemer's figure appears as if constituting a projection of the radials.

HEXACRINIDÆ W. and Sp.

MONOCYCLIC. RADIALS IN CONTACT EXCEPT AT THE POSTERIOR SIDE, WHERE THEY ARE SEPARATED BY AN ANAL PLATE. BASALS FORMING A HEXAGON. STRUCTURE OTHERWISE AS IN THE PLATYCRINIDÆ.

Analysis of the Genera.

A. BASALS 3.

1. *Costals 1 or 2.*

- | | |
|--|----------------------|
| Arms in form of main trunks giving off lateral branches; uni-serial | <i>Hexacrinus.</i> |
| Arms branching, biserial. Plates of the calyx, and some of the free brachials, covered with movable spines . | <i>Arthracantha.</i> |

B. BASALS 2.

1. *Costals 2, forming a syzygy.*

- | | |
|---|----------------------|
| Plates thin, column round | <i>Dichocrinus.</i> |
| Column crescent-shaped, giving off two rows of long cirri . | <i>Camptocrinus.</i> |

2. *Costals 1; trigonal, very small, sometimes hidden by the distichals, with first palmars touching the radials; arms biserial.*

- | | |
|---|-----------------------|
| Plates thick; anal plate in form and size resembling the anterior radial | <i>Talarocrinus.</i> |
| Anal plate much smaller than the radials; radial dome plates produced into wing-like appendages | <i>Pterotocrinus.</i> |

*Geological and Geographical Distribution.***Number of known species.**

(Open figures indicate American; those marked (), European).

FORMATION.			HEXACRINIDÆ.					
General.	American.	Approximate European Equivalents.	Hexacrinus.	Arthracantha.	Dichocrinus.	Camptocrinus.	Talarocrinus.	Pterocrinus.
Lower Carboniferous.	Kaskaskia.				3		1	3
	St. Louis.				1	1	6	
	Warsaw.				5			
	Keokuk.	Mountain Limestone.			5	1		
	Upper Burlington.				7			
	Lower Burlington.				(9) 6			
	Kinderhook.				3			
Devonian.	Chemung.			2				
	Hamilton.	Belgium.	2(3)	1				
	Upper Helderberg.	Eifel.	(21)					
Total species 85 { 52 (33)			2 (24)	3	30 (9)	2	7	8

Fig. 22.

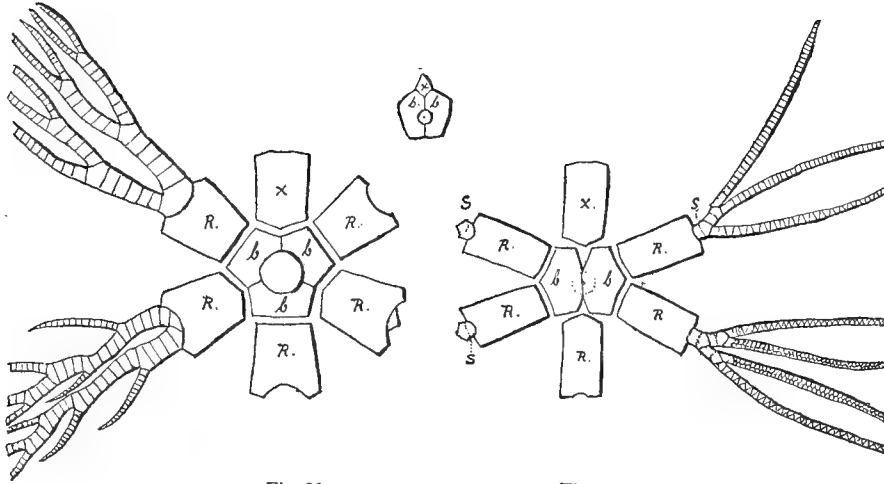


Fig. 20.

Fig. 21.

b = basals; *R* = radials; *x* = special anal plate; *s* = syzygy.

Remarks. — The Hexacrinidæ are closely allied in general structure and habitus to the Platycrinidæ, but are at once distinguished, as already pointed out in the remarks upon that family, by having a large anal plate between the two posterior radials, and a hexagonal base, the basals thus supporting six plates, instead of five. The base of the Hexacrinidæ may be composed either of three plates, or only two; but in either case the plates are substantially equal, and form a cup with six salient angles, and either two or three re-entering angles at the upper margin. When the base is bipartite, the suture runs from the anal plate to the anterior radial; but when it is tripartite, the sutures are directed to the anal plate and the right and left antero-lateral radials. In either case, therefore, there is always an interbasal suture running to the middle of the anal side, whereas in the Platycrinidæ the nearest interbasal suture to the anal side runs to the middle of the right posterior radial.

The genera which we refer to the Hexacrinidæ were always placed among the Platycrinidæ until we separated the two families,* and further investigation only confirms the validity of their separation. It is based on a fundamental structural modification, for which we find an exact parallel

* Revision, Part III., p. 93.

in the typical section of the Camerata between the Melocrinidæ and Batocrinidæ. In both cases the group with pentagonal base, and in which the anal is unrepresented, is the earliest in geological sequence.

The Hexacrinidæ have not been discovered in any formation older than the Devonian; but there they occur abundantly in the Eifel limestones, from which twenty-four species have been described. They range through the different divisions of the Subcarboniferous, and are represented in the last member of that system, the Kaskaskia group, by twelve species. Beyond that they are not known; but we shall not be surprised to hear of a Hexacrinoid being found in the Carboniferous.

The Hexacrinidæ are the only Camerata in which the arms are uniserial throughout the Devonian; they gradually become biserial in the Subcarboniferous, in the lower part of which all gradations, from uniserial to strictly biserial, are found together in the same genus.

The family consists of six genera and eighty-five species: fifty-two from America, and thirty-three from Europe.

HEXACRINUS AUSTIN.

- 1843. AUSTIN; Monogr. Rec. and Foss. Crinoids, p. 48.
- 1853. DEKONINCK and LE HON; Recher. Crin. Carb. Belg. p. 160.
- 1855. F. ROEMER; Lethæa Geog. (Ausc. 3), p. 244.
- 1857. JOH. MÜLLER; Neue Echinod. Eifl. Kalk., p. 247.
- 1857. PICTET; Traité de Paléont., Vol. IV., p. 332.
- 1862. DUJARDIN and HUPÉ; Hist. natur. des Zoöphytes Echinod., p. 155.
- 1867. SCHULTZE; Monogr. Echinod. Eifl. Kalk., p. 71.
- 1879. W. and SP.; Proceed. Acad. Nat. Sci. Phila., p. 252.
- 1881. W. and SP.; Revision Palæocr., II., p. 79.
- 1881. W. and SP.; Revision Palæocr., III., p. 116 (Proceed. Acad. Nat. Sci. Phila., p. 338).
- Syn. *Platycrinus* — PHILLIPS, 1841 (not 1836); Palæoz. Foss. Cornw., p. 28.
- Syn. *Platycrinus* — GOLDFUSS (in part); 1838, Nova Acta Ac. Leopold. XIX., p. 343.
- Syn. *Platycrinus* — AGASSIZ (in part); 1835, Mem. Soc. Neuchat. I., p. 197.
- Syn. *Platycrinus* — AUSTIN (in part); 1842, Ann. and Mag. Nat. Hist., Vol. X., p. 109.
- Syn. *Platycrinus* — C. F. ROEMER; 1843, Verstein des Harzgebirges, p. 9.
- Syn. *Platycrinus* — F. A. ROEMER; 1844, Rheinisch. Uebergangsgebirge, p. 63.
- Syn. *Platycrinus* — F. A. ROEMER; 1851, Verhandl. naturh. Vereins f. Rheinlande, p. 362.
- Syn. *Platycrinus* — LYON; 1860, Trans. Amer. Philos. Soc., Vol. XIII., p. 459.

The dorsal cup composed almost exclusively of basals and radials; the latter enclosing a large anal plate. The basals consist of three subequal pieces, forming together a rather large, more or less deep cup or basin, hexagonal in outline. Radials large, subquadrangular; their superior faces excavated so as to form a facet for the reception of the costals; the limbs slightly truncated to receive the first row of interradians. The intervening

anal plate is generally of the same size as the radials, but obtusely angular at the lower face, and broadly truncate at the upper. Costals one or two; very small, in most cases not filling the whole width of the facet. When two costals are represented, the plates are closely united, and form a syzygy. Arms, so far as known, consisting of ten stout main trunks, with armlets from one or both sides at intervals. Main arms as well as armlets composed of quadrangular, single joints, and the plates of both pinnule-bearing, except the axillary ones. The pinnules are given off, so far as observed, from one side of the arms only, not alternately from opposite sides.

The first interrarial row of plates consists of one or three pieces, which are in contact with the lower brachials, and occupy the peripheral portions of the calyx. They are followed by inter-ambulacra which enclose the orals. Ventral disk from low-convex to hemispherical; the plates more or less nodose. Orals generally well defined; the posterior one largest, almost central, and pushed in between the other four. The plates covering the food-grooves consist either of a few large plates, or of two rows of small pieces, alternately arranged.

Column round; axial canal small and circular.

Distribution. — *Hexacrinus* is restricted to the Devonian. From America only two species are known, both from the Hamilton group, and of these but one or two specimens have been obtained; while in Europe the genus is represented by many species, and specimens are quite abundant.

Type of the genus: *Hexacrinus melo* Austin.

Remarks. — It is worthy of note that the two American species of *Hexacrinus* have two costals, while the European, so far as known without exception, have but one. They agree, however, in other respects so closely that we doubt the propriety of making this a generic distinction, especially as the two plates obviously form a syzygy, and take the place of one.

***Hexacrinus occidentalis* W. and Sp. (nov. spec.).**

Plate LXXVIII. Fig. 10.

A small species. Dorsal cup higher than wide, broadly truncate at the base, very gradually spreading to the arm bases; the sides a little convex; the plates moderately thick and without ornamentation; the suture lines indistinct.

Basal cup projecting laterally in form of a rim; its lower face slightly excavated for the reception of a large stem. Radials about one third longer than wide, a little wider at the top than at the bottom; facets for the reception of the costals about two-thirds the width of the plates; semicircular, and somewhat thickened at the lower margin; the limbs but slightly truncated. Costals two, forming a syzygy, the lines of union obscure; the hypozygal joints very short and subquadrangular, the epizygal, of which the lower part is placed within the facet, considerably longer and pentangular. Arms ten; stout, cylindrical, composed throughout of rather long, single joints, of which the upper and lower faces are parallel; the main trunks giving off armlets, one from each fifth or sixth joint, the intervening joints pinnule-bearing. The armlets extend to the same height as the main arms, but have only half their width. Both are composed of quadrangular joints, which are somewhat shorter than wide; while the pinnules are short, and their joints fully twice as long as wide. Armlets and pinnules are borne only on one side of the arms: in the anterior ray from the inner side, in the lateral rays from the outer one. There is but one interbrachial plate, but this was apparently followed by several rows of small, nodose, interambulacral pieces. Form and position of anus unknown. Column round; the nodal joints considerably widest, and distinctly rounded at their edges.

Horizon and Locality. — Hamilton group, near Davenport, Iowa.

Type in the Museum of the Davenport Academy of Natural Sciences.

Remarks. — This species is peculiar for its arm structure, but still more for the arrangement of the pinnules. In the latter point it approaches *Anomalocrinus caponiformis*; but while in that species the position of the pinnules changes from one side to the other after each bifurcation, in this they are apparently given off from the same side throughout the full length of the arm.

Hexacrinus Leai (LYON).

Plate LXXVIII. Figs. 12a, b.

1869. *Platycrinus Leai* — LYON; Trans. Amer. Phil. Soc. Phila., Vol. XIII., p. 459, Plate 24, Figs. *g. gl.*

1881. *Hexacrinus Leai* — W. and Sp.; Revision Palæocr., Part II., p. 80.

1889. *Platycrinus Leai* — S. A. MILLER; N. Amer. Geol. and Palæont., p. 271.

Of moderately large size. Dorsal side of the calyx semi-ovate; plates thin and without ornamentation; the suture lines not grooved and rather obscure.

Basal cup large, broadly obconical, its height about three eighths the length of the calyx to the arms, its lower end slightly projecting and truncated, the truncated part completely occupied by the large upper stem joint. Radials gradually spreading, their upper faces nearly one-third wider than the lower, and equal to the length of the plates; the lower faces in three of the plates a little convex, in the two meeting the interbasal sutures slightly angular; facets deep, semicircular. The outer surface of the radials is marked by a median ridge, rather faint at the lower end, but growing wider and quite prominent upward. Costals two, short, twice as wide as long, rounded on the back. Of the distichals only two single plates are preserved; they are as wide as, but shorter than, the costals, and are connected laterally. All other parts wanting in the two type specimens, with the exception of a few joints of the stem, which are round and extremely short. The nodal joints are very much the widest, their projecting edges exceedingly thin and knife-like; while the edges of the internodal joints are rounded.

Horizon and Locality.—Lower part of Hamilton group; Louisville, Ky.

Type in the collection of the late Major S. S. Lyon.

ARTHRACANTHA WILLIAMS.

1883. H. S. WILLIAMS; *Proceed. Amer. Philos. Soc.* (April), p. 84.
 1885. W. and Sp.; *Revision, Palæogr.*, Part III., p. 116 (*Proceed. Acad. Nat. Sci. Phila.*, p. 338).
 1887. WHITEAVES; *Contr. to Canad. Palæont.*, Vol. I., p. 96.
 1889. S. A. MILLER; *N. Amer. Geol. and Palæont.*, p. 225.
Syn. Hystricinus HINDE; 1885, *Ann. and Mag. Nat. Hist.*, p. 158.

Plates arranged as in *Hexacrinus*, but covered with numerous tubercles, each of them having a small pit for the reception of a movable spine. Basals three, large, subequal, and pentangular. Radials and anal plate as in *Hexacrinus*. Costals two, comparatively large, and forming part of the dorsal cup. Distichals three to four, small, curved like arm plates and directed outward; those of the same ray separated by interaxillaries or in contact laterally. Arms branching, biserial; pinnules of moderate size.

Interradial plates numerous, covered like the plates of the dorsal cup, with irregularly arranged, spine-bearing tubercles. Anal opening excentric. Column round.

Distribution.—Upper Devonian, and only found in the neighborhood of Lake Ontario.

Type of the genus: *Arthracantha ithacensis* Williams.

Remarks. — The form under consideration was defined in 1883 by Williams as *Arthroacantha*, but the name was afterwards changed by Hinde to *Hystericrinus*, because it was, as he maintained, incorrectly formed, and a name too similar to *Arthracanthus*, previously employed by Schmarda for a genus of Rotatoria. We have formerly in Part III. of the Revision expressed the opinion that according to the rules of nomenclature Williams' name would have to be retained, as it was sufficiently distinct from the other, even if changed to *Arthracantha*. The same view of the case was taken by Professor Whiteaves and Mr. S. A. Miller, both accepting Williams' name. If the question were to be decided by some authoritative body of naturalists, we should vote in favor of suppressing *Arthroacantha* and legitimizing Hinde's name, on the ground that no author should be permitted, at this day, to establish a genus of Crinoids under any name which does not end with the recognized termination — "*crinus*." As it is, we have concluded, though with much reluctance, to retain the name proposed by Williams, but writing it *Arthracantha*.

Arthracantha is closely allied to *Hexacrinus*, from which it differs in having biserial arms, and movable spines upon the calyx and arms. The spines were probably attached to the plates by elastic ligaments, so as to yield when accidentally brought in contact with other objects; but we doubt if they represent either functionally or structurally the spines of the Echini. In this we differ from Williams, who thought that this structure establishes a relationship between Crinoids and Perischoechinoidea. He compares them with the spine-bearing plates of *Lepidocentrus eifelianus* Müller, and is led to believe that these were probably plates in the "vault" of a true Crinoid like *Arthracantha*. We can see nothing to support this view; the Eifel species is undoubtedly an Echinoid, and the plates of the two forms have a superficial resemblance, but are not homologous. The movable spines of *Arthracantha*, in our opinion, represent the sharp point of an ordinary spiniferous Crinoid plate, united with the basal portion by ligaments, and as such are of but little importance in classification. We therefore consider the mobility of the spines of only generic importance, differing therein from Williams and Hinde, who were inclined to make *Arthracantha* the type of a distinct family.

Arthracantha ithacensis WILLIAMS.*Plate LXXVI. Figs. 1a, b, c.*

1883. WILLIAMS; Proceed. Amer. Philos. Soc., p. 85, with a plate.

1885. W. and SP.; Revision Palæocr., Part III., p. 119.

Specimens rather below medium size. Calyx obconical, more rapidly spreading to the basi-radial suture than from there upwards. The dorsal cup as wide as high; the ventral disk flat, a little depressed in the middle.

Basals forming a low, obconical cup, with six well defined salient and three re-entering angles; the latter facing the distal ends of the interbasal sutures. Suture lines faintly grooved; the column facet small and round. Radials rapidly spreading; their upper faces one third wider than the lower, and about equal to the length of the plates; facets somewhat projecting and occupying from one third to one half the width of the upper faces; the limbs at both sides slightly inflected. Costals two, fully twice as wide as long; the upper one sharply angular above, its sloping upper faces concave. Arms free beyond the first distichals; branching, divergent, bifurcating at least twice; composed of two series of deeply interlocking plates, from which at both sides are given off delicate thread-like pinnules. The anal plate has the same form as the antero-lateral radials, all being slightly angular below. The arrangement of the plates in the ventral disk is not satisfactorily shown in the specimens; enough is seen, however, to show that there are five sets of rigid covering pieces above the food grooves, which branch close to the arm bases, each set composed of two rows of plates alternately arranged. The covering pieces are formed into rounded ridges, which grow more prominent as they approach the arms. The interbranchials consist of three plates, followed by several rows of interambulacral pieces, and these by the orals. The anus is excentric, surrounded by a number of moderately small, slightly convex pieces, which form a little rounded protuberance near the outer margin of the disk. Calyx and arm plates profusely covered with spine-bearing tubercles, of which there are thirty to thirty-five upon each radial, and a proportionate number upon the basals; the costals apparently have two, the free arm plates and the covering pieces one each. The tubercles are wanting, so far as observed, on the interambulacral plates, except upon the anal side. The tubercles are of nearly uniform size; circular, rounded and narrower at the top, and pitted at the apex for the reception of the

spine. The spines, which bristle upward and outward, are acicular, very long and slender, varying in length from ten to twelve mm., somewhat thicker near the proximal end, and slightly pitted at the bottom. Column round and comparatively thin.

Horizon and Locality. — Chemung group, Ithaca division; Ithaca, N. Y.

Types in the collection of Prof. Henry S. Williams at Cornell University.

Remarks. — The description was made from natural moulds formed in the rock after disintegration of the calcareous test, and from gutta percha casts therefrom.

***Arthracantha punctobrachiata* WILLIAMS.**

Plate LXXVI. Figs. 2a, b.

1883. WILLIAMS; Proceed. Amer. Philos. Soc. (April), pp. 83 and 86.

1885. W. and Sr.; Revision, Palæocr., Part III., p. 119.

1887. WHITEAVES; Contr. to Canad. Palæont., Vol. I., p. 93, Plate 13, Figs. 1, 1a.

Syn. *Platycrinus* (?) *punctobrachiatus* HALL (figured by Hall 1872, in Bull. I. N. Y. State Museum Nat. Hist.).

Syn. *Hystericrinus Carpenteri* HINDE, 1885; Ann. and Mag. Nat. Hist., p. 162, Plate 4.

Dorsal cup obconical; more rapidly spreading at the basals than at the radials; the latter somewhat inflected at the upper ends. Ventral disk hemispherical, flattened in the central part. Plates without ornamentation, but thickly covered by minute spine-bearing tubercles, which, when well preserved, resemble small cones truncated at the upper end. The spines are elongate, cylindrical, and measure from fifteen to thirty-five mm. in length; they have a short neck at the proximal end, and taper distally. The distribution and arrangement of the tubercles is quite irregular; they are, as a rule, more numerous upon the basals and radials, but the number varies even among corresponding plates of the same individual. There are but very few upon the distichals and interbrachials, but they are crowded along the median portions of the disk, where, according to Hinde, they are shorter and comparatively thicker than at the arms.

Basals large, almost of uniform size; the suture lines indistinct; the lower end truncated to the width of the column. Radials somewhat irregular in form, the two facing the anal plate narrower at the lower face than at the upper, and narrower throughout, the others almost rectangular, and nearly as long as wide. The upper faces are straight, except the median part, which is slightly excavated for the reception of the costals; the outer faces

angular along the median line. Costals two; the first narrow and very short; the second sharply angular above; its sloping upper faces concave. Distichals three in the calyx; those of the same ray in contact laterally, or separated by an interdistichal. Arms biserial, generally from the first free plate. There are three interbranchials to each regular interradius, of which the inner one is larger than the two outer, the latter curving outward so as to meet the distichals. The interbranchials are followed by numerous rows of small, rigid interambulacral pieces, of which the upper ones from each side meet in the summit, there being apparently no orals. The first anal plate is narrower than the radials; it is succeeded by five plates, of which the middle one is larger and somewhat bulging. Anus excentric, placed within a small protuberance. Column round, formed at its upper end of short joints with sharp, knife-like edges.

Horizon and Locality. — Hamilton group; Arcona and Bartlett's Mill, Ontario, Canada.

Remarks. — Dr. G. J. Hinde described this species as *Hystericinus Carpenteri*. We have heretofore, in Part III. of the Revision, stated that in our opinion Williams' prior name should be retained. Williams' description, although merely comparative, is amply sufficient for the identification of the species; this view is also held by Professor Whiteaves and Mr. S. A. Miller.

***Arthracantha depressa* W. and Sp. (nov. spec.).**

Plate LXXVI. Figs. 3a, b.

Dorsal cup short, twice as wide as high. Basals so closely anchylosed that the lines of union are rarely seen; they form a very shallow, hexagonal basin, which near its outer margin is surrounded by two indistinct corrugated ridges. A single ridge, even more obscure, follows the lower margins of the radials, parallel to the basi-radial sutures. Radials once and a half as wide as long, their lower faces nearly straight, the upper ones to fully one half their width deeply excavated, their outer ends truncated and distinctly sloping. Costals two, on the same plane with the radials, unusually large for the genus, both of them constituting a part of the dorsal cup; they are three times as wide as long, and of a similar form, except that the first is angular below, the second angular above. Of the distichals only the two lower ones take part in the calyx; they are quadrilateral, and twice as wide as the succeeding ones. The free distichals are cuneate to the second or third

plate, above which the arms are biserial and widely divergent. Whether they branch again is not known. There is but one interbrachial at the four regular sides, which is located within the dorsal cup; it is wider than long, very large, and extends to the full height of the distichals. The ventral disk is quite low, and depressed in the central portions, the ambulacra conspicuously projecting, especially on approaching the arms. The posterior area is wide, bulging, and composed of a great number of plates, which form a large, rounded protuberance containing the anal opening, which is directed upward and surrounded by very minute pieces. Orals arranged in the usual way; the posterior one large, its diameter shorter from the anterior to the posterior side. The plates covering the food-grooves rather large; consisting of two rows of pieces alternately arranged. The sockets for the reception of the spines rather irregularly distributed and far apart; they are large and circular, and have a shallow pit at the upper face. The form of the spines is not known, but they were evidently large.

Horizon and Locality. — Lower Chemung group; Steuben Co., N. Y.

Types in the collection of Wachsmuth and Springer.

Remarks. — This species is known only from natural moulds and gutta percha casts. We had for description two specimens, one showing the dorsal cup, the other the ventral disk, both presented to us by Prof. J. M. Clarke of Albany. The species is readily distinguished from *Arthracantha punctobrachiata* Williams by the more depressed form of the calyx, the greater width of the costals, the presence of but one interbrachial piece and the fact that this is located almost entirely in the dorsal cup, and by the less number and greater width of the spine-bearing sockets.

DICHOCRINUS MÜNSTER.

1838. MÜNSTER; Beitr. zur Petrefactenkunde, I., p. 2.
 1843. AUSTIN; Monogr. Rec. and Foss. Crinoids, p. 45.
 1850. D'ORBIGNY; Prodr. de Paléont., I., p. 156.
 1852. OWEN and SHUMARD; Geol. Rep. Iowa, Wisc., and Minnesota, p. 589.
 1853. DE KONINCK and LE HON; Rech. Crin. Carb. Belg., p. 146.
 1857. PICTET; Traité de Paléont., Vol. IV., p. 333.
 1860. MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 381.
 1860. HALL; Suppl. Geol. Rep. Iowa, p. 83.
 1860. CASSEDAY and LYON (in part); Proceed. Acad. Arts and Sci., Vol. V., p. 16.
 1861. HALL; Bost. Journ. Nat. Hist., Vol. XII., p. 288.
 1862. DUJARDIN and HUPÉ; Hist. naturelle des Zoophytes Échin., p. 155.
 1862. WHITE; Proceed. Bost. Journ. Nat. Hist., Vol. IX., p. 19.
 1866. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., pp. 167 and 263.
 1879. ZITTEL; Handb. der Palæontologie, Vol. I., p. 365.
 1881. W. and SP.; Revision Palæocr., Part II., p. 81.
 1882. DE LORIOU; Paléont. Française, Crinoides, Part I., p. 33.
 1883. WORTHEN; Geol. Rep. Illinois, Vol. VII., p. 313.
 1885. W. and SP.; Revision Palæocr., Part III., p. 119 (Proceed. Acad. Nat. Sci. Phila., p. 341).
 1890. W. and SP.; Geol. Rep. Illinois, Vol. VIII., p. 190.
 1890. S. A. MILLER; North Amer. Geology and Palæontology, p. 239.
 Not Hall 1858; Geol. Rep. Iowa, Vol. I., Part II., pp. 654 and 689; nor Shumard 1857; Trans. St. Louis Acad. Nat. Hist., Vol. I., p. 5.
 Syn. *Platycrinus* (in part) — PHILLIPS; Geol. of Yorkshire, Vol. II., Plate 3, Figs. 24 and 26.
 Syn. *Cotyledonocrinus* — CASS. and LYON. 1860, Proc. Am. Ac. Arts and Sci., V., p. 26.

Calyx oblong, conical to almost cylindrical. The dorsal cup consists almost exclusively of basals, radials, and a large anal plate. The costals and distichals, although laterally connected by interbrachials, and taking part in the composition of the calyx, more or less, retain the form of arm plates. Plates delicate; their surfaces smooth, or covered with longitudinal striæ or rows of small tubercles. Basals two, the suture line running from the anal plate to the anterior radial. They form together a deep obconical or rounded cup, which in height often equals the length of the radials. Radials large, subquadrangular, except the anterior one, which is pentangular; their upper faces excavated for the reception of the brachials. Costals two, very short and narrow. In some species the axillary costals support the arms, in others those of the distichals or palmars, and the first and second plate of each order are united by syzygy. Arms thin, either uniserial or biserial, sometimes pendent. Pinnules unusually long and rather stout. Interbrachials three, arranged transversely; they rest upon the upper faces of the radials and are succeeded by a number of interambulacral pieces. The covering plates of the ambulacra generally exposed and forming continuous rows. Anal plate frequently a little smaller than the radials, pentangular, narrower at the upper end than at the lower. Anus excentric, placed within a wart-

like protuberance, or at the outer end of a short conical tube. Column round; axial canal minute.

Distribution. — This genus is largely represented in, and nearly to the close of, the Carboniferous, both in America and Europe; but not a solitary species is known from the Devonian, nor from the Coal measures.

Type of the genus: *Dichocrinus radiatus* Münster.

Remarks. — There has been some difference of opinion as to the number of "primary radials" in *Dichocrinus*. The Austins represent their *D. fusiformis** with three costals, and De Koninck and Le Hon, in their generic formula, fix the number of "primary radials" at four, on the strength of Austin's figure. Shumard, on the other hand, describes two of his species, *D. cornigerus* and *D. sexlobatus*, with a single large radial followed directly by the distichals. Casseday and Lyon give the number of "radials" as one to three, and with this Meek and Worthen agree.

From a careful examination of extensive material, we are convinced that all species of *Dichocrinus* have three so-called radials, *i. e.* two small costals above the radial, united by syzygy; but that *D. cornigerus*, *D. sexlobatus*, and the other species for which we proposed the genus *Talarocrinus*, have but one, and this so extremely small that it was overlooked by Shumard.

The genus *Cotyledonocrinus* Casseday and Lyon is based on incorrect observation. Examination of the type specimens shows that *C. pentalobus*, the type of the genus, has two basals, followed by a ring of six plates, and not by five as described by the authors.

***Dichocrinus lachrymosus* HALL.**

Plate LXXVII. Figs. 2a, b, c.

1859. *Dichocrinus lachrymosus* — HALL; Suppl. Geol. Rep. Iowa, p. 84; figured Bull. I. N. Y. State Museum of Nat. Hist., Plate 2A, Fig. 11.

1881. *Platycrinus subspinosus* — W. and SP.; Revision Palæocr., Part II., p. 75.

1885. *Dichocrinus lachrymosus* — W. and SP.; *ibid.*, Part III., p. 119.

A rather large and grotesquely ornamented species. Calyx large in proportion to the size of the arms, broadly conical, as wide as high; sides rapidly and uniformly spreading from the base of the basal cup to the base of the brachials; the radials rounded on the back, producing angular depressions along the suture lines. Surface of plates covered by series of prominent wart-like processes of abrupt and irregular form, those of the same plate being generally confluent. On the basal cup, these processes occupy the lower end, there being two or three of them to each basal, each set separated

* Rec. and Foss. Crin., Plate 5, Fig. 6b.

by an obscure groove, and similar grooves, but deeper, mark the interbasal suture lines. The processes upon the radials occupy the upper two thirds of the plates, leaving their lower ends and the upper portions of the basals almost free from ornamentation. The facet which supports the costals is surrounded by a thickened collar, from which three — exceptionally two — ridges or series of nodes pass downward; the two outer ones in the direction of the lower angles of the plates, the other following the median line.

Basal cup large, occupying over two fifths the height of the calyx. Radials considerably wider above than below, their length about equal to their width at the upper end; the lower faces very little convex, the upper slightly excavated; the facet directed upwards, occupying one third the width of the plates; the limbs somewhat inflected but not notched. Costals two, rounded on the back, the lower very short and linear; the second a little longer and axillary, its sloping upper faces at right angles. Distichals three, narrower than the costals; the two lower ones combined but little longer than the third, and united by syzygy, the second giving off a strong pinnule to the outer sides of the rays; the third axillary. Arms generally four to the ray, occasionally five to six in one of the three anterior rays, or in all of them; they are widely divergent, comparatively thin, rather short, and composed of a single series of cuneate pieces alternately arranged. Ventral disk depressed-convex, the median portions flattened and occupied by five, small but well defined orals, from which five rows of comparatively wide but short covering pieces pass out to the arms. The three interbrachial plates are followed by eight to ten interambulacral pieces, distributed in four ranges. Anal plate a little narrower at the top than below, succeeded by five small pieces transversely arranged, which in turn are followed by numerous smaller plates forming a protuberance which contains the anal opening. The anus is almost marginal and opens out laterally. Column small, round; the joints short, the nodal ones somewhat projecting.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Type in the (Worthen) Illinois State collection.

Remarks. — This species is readily distinguished from any other of this genus by its peculiar style of ornamentation, in which, however, it closely resembles *Platycrinus subspimulosus* Hall, to which we erroneously referred it in Part II. of the Revision. The type specimen, which we had examined, was imperfect, showing neither the anal plate nor the form of the calyx. Fine specimens since obtained by us in considerable number leave no doubt that it is an exceedingly well marked species, and was correctly described as a *Dichocrinus*.

Dichocrinus polydactylus CASSEDAY and LYON.*Plate LXXVII. Figs. 1a, b.*

1860. CASSEDAY and LYON; Proceed. Amer. Acad. of Arts and Sci., Vol. V., p. 18.

1881. W. and SP.; Revision Palæocr., Part II., p. 84.

Syn. *Dichocrinus expansus* MEEK and WORTHEN (not De Koninck and Le Hon 1853); Proceed. Acad. Nat. Sci. Phila., p. 344; also Geol. Rep. Illinois, Vol. V., p. 500, Plate 14, Fig. 1.

Of the type of *D. lachrymosus*. Calyx expanding rather rapidly along the basals, thence more abruptly to the top of the radials, where its width is once and a half its height. The calyx in a dorsal aspect is sharply hexagonal, owing to the convexity of the radials and anal plate, especially in the upper parts where the median portions are conspicuously gibbous, producing an angular depression along the interrarial sutures. The basi-radial and interbasal sutures are also slightly grooved, and the margins of the plates somewhat beveled. Surface of plates ornamented with scattered, irregular, wart-like nodes, which show a tendency to form vertical rows. Similar markings occur upon the radials, where they start from the projecting upper rim and run to the lower end of the plates.

Base large, its height almost one half that of the entire cup; its lower face surrounded by conspicuous nodes, which are sometimes confluent and form a rim around the lower margin. Radials nearly twice as wide at the upper end as at the lower, the upper face almost equal to the length of the plates; the facet bounded by a heavy, thickened rim. Anal plate wider and longer than the radials, strongly convex in the middle, somewhat inflected at the top. Costals two, twice as wide as long. Distichals three; the first and second, like the first and second costals generally united by syzygy, their suture lines being less distinct than those between the other brachials; the third distichal largest and axillary; it supports on its outer face a simple arm, which slopes obliquely upward, and on the inner face two palmars arranged almost in vertical line with the distichals, and resembling them in form and size. The second palmar bifurcates again, giving off in the same manner as the preceding axillary an arm from the outer side, and from the inner two or three post-palmars, which support two simple arms, making four arms from each main division, or eight from each ray. Arms biserial from the fourth or fifth plate; they are long, rounded on the back, and taper very slightly; pinnules closely set and of moderate length. Ventral disk higher than the dorsal cup, composed of comparatively large plates;

the summit somewhat flattened and covered by large orals, from which two rows of tuberculous covering pieces pass out to the arms. Interradial spaces slightly depressed and paved by numerous rather large plates, all having a small tubercle in the centre; the anal interradius has five plates in the first row as against three at the other sides, and is very wide and bulging, the plates throughout being large, except those immediately surrounding the anus. The anal opening is placed near the summit in close proximity to the posterior oral. Column round, of moderate size, slightly tapering downward, the nodal joints but little wider than the internodals.

Horizon and Locality.—Keokuk limestone; Crawfordsville, Ind.

Types in the collection of the late Major Sidney S. Lyon, Jeffersonville, Ind.

Remarks.—*Dichocrinus expansus* Meek and Worthen is undoubtedly identical with this species, although the specimen figured has only six arms to the ray. Moreover, that name was pre-occupied by De Koninck and Le Hon in 1853.

***Dichocrinus striatus* O. and SHUM.**

Plate LXXVII. Figs. 11a, b.

1852. OWEN and SHUMARD; U. S. Geol. Rep. Wisc., Iowa, and Minn., p. 590, Plate 5A, Figs. 10a, b.

1881. W. and SP.; Revision Palæocr., Part II., p. 85.

Calyx subglobose, widest at the basi-radial suture; composed of thin plates, which are thickly covered with conspicuous, abruptly elevated, longitudinal ridges. These ridges form around the calyx six well defined rhombs, which meet interradially at the basi-radial suture, the acute upper angles of five of them reaching to the radial facets, that of the sixth to the upper part of the anal plate, and their lower angles to the lower ends of the basals. The rhombs are subdivided into two triangles by the basi-radial suture, and the included spaces are occupied by three or four vertical ridges, often with smaller ones between, which all cross the suture line unbroken. Other ridges, but less distinct and easily overlooked, fill the triangles formed between the upper sides of adjoining rhombs, and these as well as those within the rhombs, when examined under a lens, have an undulated outline.

Basal cup hemispherical, slightly truncated at the lower end; column facet well defined and bordered by the lower ends of the ridges; height equal to that of the radials; superior margin distinctly hexangular. Radials quadrilateral, narrower at the top than at the bottom; the width at the lower faces

equal to, or greater than the length; their upper faces one third narrower; facets semicircular, directed upward, and occupying one half the width of the plates. Anal plate of a similar form to the radials, but narrower at the top, the upper portion somewhat bulging. Costals two, very short. Arms two from each ray, rather strong, biserial from the fifth plate; flattened on the back. Arm joints twice as wide as long. Pinnules heavy and unusually long even for this genus. Column small; the nodal joints considerably widest, and their edges knife-like and serrated.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa, and several places in western Illinois and Missouri.

Dichocrinus plicatus HALL.

Plate LXXVII. Figs. 5a, b.

1861. HALL; Boston Journ. Nat. Hist., Vol. VII., p. 288.

1881. W. and SP.; Revision Palæocer., Part II., p. 84 (Proceed. Acad. Nat. Sci. Phila., p. 258).

Of the type of *D. striatus*, which it resembles in the style of ornamentation; but the plates are thicker, the ridges upon the plates comparatively larger, less in number, and the species is smaller throughout. Calyx globular, slightly conical at the lower end; greatest diameter at the lower part of the radials, the upper part curving gradually inward. The ribs or ridges covering the surface are undulated and very strong, the intervening grooves deep and wider in the middle than at the ends. They form six well defined rhombs, distributed around the calyx in a similar manner as those in the preceding species; but their inner spaces are occupied by one or two in place of three to four ridges, and the triangles at each side of the rhombs, which are longitudinally divided by the interrarial sutures, are smooth or only occupied by low pustules.

Basals longer than the radials, forming a deep cup with rounded sides and slightly truncated lower end. Radials subquadrangular, widest at the lower margin; facets wide, occupying two thirds the width of the plate, and directed upward. Anal plate generally a little narrower than the radials. Costals two, small, supporting two arms. Arms thin, long; composed of rather long cuneate pieces, which interlock from the fourth or fifth plate. Pinnules stout and very long, the joints three times longer than wide. Column small.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Types in the Museum of Comparative Zoölogy.

Dichocrinus oblongus W. and Sp. (nov. spec.).*Plate LXXVII. Fig. 9.*

In the style of ornamentation resembling *D. striatus*, from which it differs essentially in its very elongate calyx, and in the proportions of the plates. Calyx almost twice as high as wide, obconical, not contracted at the upper end; the sides convex. Surface covered by six sets of from five to six rather prominent, longitudinal ridges, which in gentle curves pass from the facets of the radials and top of the anal plate to the foot of the basals. These ridges do not cover the entire surface of the calyx, but leave upon the lateral margins of adjoining radials a trigonal space, divided by the interrarial suture, and covered by obscure, longitudinal ridges, which rest obliquely against the other ridges.

Basal cup conical, almost as high as the radials, and nearly as high as wide; slightly truncated at the bottom; the upper face but little excavated. Radials once and a half as long as the width of the lower end, a little wider above than below, the lower face almost straight; facets narrow, a little concave, and slightly protruding outward. Structure of arms and ventral disk not known.

Horizon and Locality. — Warsaw limestone, near Bloomington, Ind.

Type in the collection of Wachsmuth and Springer.

Dichocrinus liratus HALL.*Plate LXXVII. Figs. 3a, b, and Plate LXXVI. Fig. 8.*

1860. HALL; Prelim. Descr. of New Palæoz. Crin., p. 5.

1861. HALL; Bost. Journ. Nat. Hist., Vol. VII., p. 290.

1872. HALL; N. Y. State Mus. Nat. Hist. (Bull. I.), Plate 2A, Figs. 7, 8.

1881. W. and Sp.; Revision Palæocr., Part II., p. 84.

Of the type of *D. polydactylus* and *D. lachrymosus*, differing from the former in having four or five instead of six to eight arms to the ray, and showing a tendency toward the rhombic sculpturing of *D. striatus*. Calyx abruptly spreading to the basi-radial suture, and more moderately from there to the arm bases, at which the width is about equal to the length. Surface marked by a few strong radiating ridges, somewhat tending to form triangles or rhombs, modified by transverse lines; composed of small, closely

set, bead-like processes, which give to the ridges a somewhat serrated aspect. Suture lines obscure.

Basals large, occupying two fifths to one half the height of the dorsal cup, their lower ends projecting into a salient margin; their surface covered with eight ridges, six of them radiating from the column to the six salient angles which form the upper margin of the dorsal cup; the two others follow the interbasal suture. Radials as long as their width at the top, the median portions obtusely angular, projecting outward, especially in the upper part, where the outer margins of the plates form a depression or groove along the interrarial sutures; the outer edges of the facets surrounded by a large, quite prominent, thickened rim, from which two ridges pass out to the lower angles of the plates. The spaces between these ridges and those of the basals are marked with a few small nodes, which below the basi-radial suture are arranged in transverse lines. The upper lateral angles of the radials are not truncated, and the facets are shallow. Anal plate similar in form to the radials, but narrower and angular at the top. Costals two, short, and closely united. Distichals three; the length of the two lower plates together about equal to that of the third. Arms four to the ray, subcylindrical, very little tapering; composed of two rows of rather large interlocking pieces. Pinnules long. Structure of the disk not known. Column round and of moderate thickness; the joints very even and short near the calyx, but growing longer downward, and the nodal joints projecting above the internodals.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Type in the University Museum at Ann Arbor, Michigan.

Dichocrinus ovatus O. and SHUM.

Plate LXXVI. Fig. 7, and Plate LXXVII. Figs. 8a, b.

1852. OWEN and SHUMARD; U. S. Geol. Rep. Wisc., Iowa and Minn., Part II., p. 590, Plate 5A, Figs. 9a, b, c.

1881. W. and SP.; Revision Palæocr., Part II., p. 84.

Form of calyx ovoid, higher than wide, widest across the middle of the radials; the edges of the plates slightly beveled, and the suture lines well defined; plates strong. The basals form a rounded, somewhat conical cup, which at its lower end is truncated and slightly excavated. The truncated part is completely filled by the upper face of the column, and there is around its edge a ring of well defined spinous nodes. The sides of the cup are

densely covered by small granules arranged in rows, some of which run from the truncated lower part to the upper faces, and a somewhat stronger one to each angle; others run parallel to the undulating upper margin.

Basals large, occupying more than three eighths the height of the calyx. Radials variable in form, but always longer than wide, and narrower at the upper face than at the lower; their ornamentation is similar to that of the basals, consisting of narrow rows of granules passing up and down the plates, and others crossing them transversely; facets occupying about one half the width of the radials at their upper end, shallow, and directed upwards. Anal plate generally wider at the bottom than the radials, and narrower above; the lower faces distinctly angular. Costals two; the first shorter than the bifurcating second. Arms ten, strong, slightly tapering upward, and biserial. Pinnules very long and closely packed; composed of six or seven joints, each one about eight times as long as wide. Structure of the ventral disk, and form and position of the anus unknown. Column round, the nodal joints larger and rounded at their edges, the internodals quite short.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

***Dichoerinus lineatus* MEEK and WORTHEN.**

Plate LXXVI. Figs. 4a, b, c.

1869. MEEK and WORTHEN; *Proceed. Acad. Nat. Sci. Phila.*, p. 69.

1873. MEEK and WORTHEN; *Geol. Rep. Illinois*, Vol. V., p. 440, Plate 3, Figs. 1a, b, c.

1881. W. and SP.; *Revision Palæocr.*, Part II., p. 84.

A large species, intermediate between *D. ovatus* and *D. pisum*, with delicate longitudinally striate ornamentation. Calyx pyriform, about as wide as high, not rounded at the base as in the former, nor flattened as in the latter; it is widest at midway, and contracts but little at the upper end. Surface densely and uniformly covered with minute, closely arranged longitudinal ridges, proceeding in parallel lines from the upper part of the radials downward; those following the median portions of the plates continuous to the foot of the basal cup, the outer ones meeting at acute angles with corresponding ridges from adjacent radials. On the anal plate, in which the upper face is much narrower than the lower, the ridges run parallel to the lateral margins of the plate, and meet the inner ridges at acute angles in a similar manner to those upon the basals.

Basal cup conical, with slightly curving sides; its height equal to the length of the radials. Basi-radial and interrarial sutures rather well defined.

Radials a little longer than wide; the lower faces moderately convex; the lateral ones parallel; the upper nearly straight, not sloped at the outer ends, and but little impressed at the facet, which is narrow and somewhat thickened around the margin. Anal plate generally wider at the lower end than the radials, and one fourth narrower at the top; its lower face obtusely angular. All parts above the radials unknown. Column round and small.

Horizon and Locality. — Lower Burlington limestone, Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

***Dichocrinus ornatus* W. and SP.**

Plate LXXVII. Fig. 6.

1881. *Dichocrinus ornatus* — W. and SP.; Revision Palæocr., Part II., p. 84.

Syn. *Dichocrinus sculptus* — CASSEDAY and LYON (not De Koninck and Le Hon, 1853); Proceed. Amer. Acad. Arts and Sci., Vol. V., p. 25.

A very small species. Calyx to the top of the radials about as wide as high; regularly cup-shaped; broadly truncated at the lower end; the sides a little convex; the upper margin slightly contracting. Plates covered by conspicuous, irregular, undulating ridges, two of which descend from the top of the dorsal cup to the foot of the basals, two others obliquely in the direction of the lower lateral angles of the radials, touching slightly the upper end of the basals, and two shorter ones pass out to the lateral faces of the radials.

Basal cup saucer-shaped, occupying two fifths the height of the calyx; the truncated lower face surrounded by a well defined undulating rim. Radials a little longer than wide, widest at the top; facets small and projecting outward. Anal plate almost as large as the radials, narrowest above. Costals two, short; occupying less than one half the width of the radials. Distichals two or three. Arms four to the ray, slender; composed of long cuneate joints which gradually interlock without being truly biserial. Pinnules long. The arms in most of the specimens are spread out horizontally. Ventral disk low-convex; anus directed laterally. Column round; the nodal joints projecting and provided with one or two long cirri.

Horizon and Locality. — St. Louis group; the type specimen in the collection of Major S. S. Lyon came from Hardin County, Ky., that figured by us from near Mt. Pleasant, Iowa.

Remarks. — This is the smallest known species of *Dichocrinus*, and is readily recognized by the spreading arms, long pinnules, and the striæ along the calyx plates.

Dichocrinus coxanus WORTHEN.*Plate LXXVI. Fig. 9.*

1883. WORTHEN; Geol. Rep. Illinois, Vol. VII., p. 313, Plate 27, Figs. 7.

1885. W. and SP.; Revision Palæocr., Part III., p. 120 (Proceed. Acad. Nat. Sci. Phila., p. 342).

A very small and slender species of the type of *D. ornatus*. Calyx ovate, almost pointed at the lower end, constricted across the costals; greatest diameter a little above the basi-radial suture. Surface of the plates covered with irregular longitudinal ridges, from three to four to each plate, which run parallel to the lateral borders of the radials, and are continued along the basals to the column.

Basals as long as the radials; forming a rather high, obconical cup, with a very narrow columnar attachment. Radials longer than wide, their lower faces moderately convex, the lateral faces nearly parallel, the upper margins constricted and to nearly one half their width excavated for the facets. Costals two, very short, forming a syzygy. Arms ten, slender, rounded on the back; composed of slightly cuneate pieces. Pinnules long. All other parts unknown.

Horizon and Locality. — Upper part of Keokuk limestone (Crawfordsville division), Hamilton, Illinois.

Type in the collection of Mr. L. A. Cox, Keokuk, Iowa.

Remarks. — *Dichocrinus ornatus*, with which this species has the closest affinities, has twenty arms instead of ten, the calyx is less contracted at the arm bases, broadly truncated at the lower end, and it comes from a different horizon.

Dichocrinus pisum MEEK and WORTHEN.*Plate LXXVI. Fig. 5, and Plate LXXVII. Fig. 10.*

1869. MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 69.

1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 441, Plate 3, Figs. 2a, b, c.

1881. W. and SP.; Revision Palæocr. Part II., p. 84 (Proceed. Acad. Nat. Sci. Phila., p. 258).

Of the type of *D. plicatus*, but the calyx, instead of globular, subquadragular in outline, the basal portions more or less flattened, and the sides along the radials but very slightly convex. It also resembles *D. lineatus* in the style of ornamentation, but the ridges are coarser and more prominent, and the basal cup proportionally smaller and less conical. Height one fourth less than the width. Plates thin; the radials covered by from six to eight

striae vertically arranged, and all continued to the basals, where the corresponding ones meet with those from adjoining radials at acute angles; the striae in well preserved specimens showing a rhombic arrangement.

Basal cup rather flat, presenting a shallow basin; the columnar attachment very small. Radials a little longer than wide; the lower faces a little convex; facets shallow, occupying about one half the width of the plates. Structure of the disk and arms unknown.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Dichocrinus cinctus MILLER and GURLEY.

Plate LXXV. Fig. 5, and Plate LXXVII. Figs. 4a, b, c.

1890. MILLER and GURLEY; Journ. Cincin. Soc. Nat. Hist., Vol. XIII., p. 21, Plate 4, Figs. 10 to 12.

A small and slender species. Calyx fusiform, widest across the middle of the radials, whence it tapers both ways; cross section circular; suture lines indistinct; surface of plates highly ornamented. The radials are covered with five or six longitudinal ridges, which follow the median portions of the plates to near the foot of the basals. The ridges do not quite reach the top of the radials, and their upper ends are rather obscure; but toward the lower end, and especially upon the basals, they grow quite prominent, and terminate in a sort of thickened collar around the column facet, giving to the specimens an appearance as if the inner part of the base consisted of an independent set of plates. The longitudinal ridges are faced laterally by horizontal ones, which traverse the interrarial sutures, and enter the margin of the adjoining plate.

Basal cup obconical, rising to two fifths the height of the calyx, the upper angles slightly bending inward; radials somewhat projecting next to the facet into a lip; facets directed upward, not occupying more than one third the width of the plates. Costals short, very closely united. Arms free after the first bifurcation; simple, slender, long, and uniserial throughout; joints convex, slightly cuneate, and very short; the two proximal ones united by syzygy, with striated, apposed faces (Plate LXXVII., Fig. 4c). Pinnules in close contact, and of moderate length and width. Anal plate longer than the radials, and more inflected at the upper end. It supports a number of small irregular plates, which form a small protuberance enclosing the anus; the latter opening out laterally. Ventral disk low-pyramidal;

the summit covered by a large, single oral plate, from the sides of which the covering pieces pass out to the arms. Column large compared to the size of the species; composed of high joints with serrated edges.

Horizon and Locality.—Kinderhook group, Le Grand, Marshall Co., Iowa.

Types in the collection of Mr. Wm. F. E. Gurley, Danville, Ills.

Dichocrinus lævis HALL.

Plate LXXVII. Figs. 7a, b, c.

1859. HALL; Suppl. Geol. Rep. Iowa, Vol. I., p. 83.

1881. W. and SP.; Revision Palæocr., Part II., p. 84.

A beautiful little species. Calyx goblet-shaped, obconical to the basi-radial suture, not expanding above; the cross section slightly hexagonal. Plates remarkably thin and flat, their surfaces thickly covered with small granules.

Basals forming a small obconical cup, which extends to about one third the height of the calyx, and sometimes a little higher. Radials nearly as long as wide; the sides parallel, except in the two posterior rays, where they are wider above; the lower faces moderately convex; the upper almost straight; facets small, occupying but one third the width of the plates; their lower margins slightly thickened. Costals two, a little wider than long; the second sharply pentangular. Distichals almost as wide as the costals, the line of union between the first and second less distinct than that between the succeeding joints; the second giving off either a very large pinnule or an arm; in the former case sometimes another bifurcation takes place higher up. Arms uniserial, long, rather stout, very little tapering; composed of cuneate joints alternately arranged, which at the tips do not touch the opposite side of the arm. Pinnules long, very stout, and not in contact; the joints as wide as long. Interradials not visible from a side view. Anal plate a little higher than the radials, narrowest at the upper end, and distinctly angular at the basi-radial suture. Anus placed near the margin of the ventral disk, in the middle of a small protuberance. Column round, small.

Horizon and Locality.—Lower Burlington limestone; Burlington, Iowa.

The specimens figured are in the collection of Mr. F. M. Fultz, of Burlington, Iowa.

Dichocrinus delicatus W. and Sp. (nov. spec.).*Plate LXXVII. Fig. 13.*

Of the type of *D. laevis*, but smaller; the calyx more elongate, its height twice its width; cross section circular; plates thin and apparently without ornamentation; suture lines indistinct.

Basals occupying two fifths the height of the dorsal cup, the sides a little convex. Radials fully twice as long as wide; the lateral faces about parallel; the upper face nearly straight, not sloping at the sides; the facet for the reception of the brachials slightly indented, occupying less than one half the width of the plates. Primary brachials two, short, of equal width; the second a little longer, its upper sides forming an obtuse angle, and giving off two arms which remain simple throughout. Arms long, cylindrical, but little tapering; uniserial, composed of very short quadrangular joints; their upper and lower faces almost parallel; the pinnules in rather close contact, long, slender. Anal plate of equal length with the radials, the upper end narrower than the lower. Ventral disk and anal opening not visible in the specimens.

Horizon and Locality. — Kinderhook group of Marshall Co., Iowa, and Lower Burlington limestone of Burlington.

Types in the collection of Wachsmuth and Springer.

Remarks. — *Dichocrinus delicatus* made its appearance before *D. laevis*, and may be regarded in a phylogenetic sense as the earlier stage of that species, as indicated by the arm structure; the arm joints are quadrangular in the several specimens found, while in that species they are cuneate and interlocking at the tips of the arms. Besides, this has invariably two arms to the ray instead of four as in *D. laevis*, and the specimens are generally smaller.

Dichocrinus superstes W. and Sp. (nov. spec.).*Plate LXXVI. Fig. 12.*

A small species of the type of *D. delicatus*. Dorsal cup obconical, higher than wide, spreading more rapidly at the basal cup than from there upwards. Cross section hexangular, owing to an angularity passing from the radial facets and upper part of the anal plate to the lower ends of the basals. Plates without ornamentation, thick, and the sutures obscure, except the interrational, which are somewhat grooved at the upper end.

Basal cup about two thirds as high as the radials; the salient angles obtuse and the intervening spaces very little concave; column facet small. Radials from one third to one half longer than wide; irregular in form, some of them much wider above than below, others of nearly equal width throughout; the upper faces distinctly sloping at the sides, forming rather deep notches for the reception of the interbrachials; facets but slightly excavated, occupying a little more than one third the width of the plates. Anal plate generally narrower than the radials. Costals two, comparatively large, supporting two simple arms, which from the third or fourth plate up are composed of two series of transverse pieces alternately arranged. The arms are heavy throughout, biserial, and rounded on the back. Pinnules cylindrical, very long and stout. All other parts unknown.

Horizon and Locality. — Kaskaskia group; Pulaski Co., Ky., and Huntsville, Ala.

Type in the collection of Wachsmuth and Springer.

Remarks. — The form of the calyx, thickness of plates, deep notches for the reception of the interradials, and the stoutness of the arms, are characters which distinguish this species readily from *D. delicatus*.

Dichocrinus scitulus HALL.

Plate LXXVIII. Figs. 13a, b, and 14.

1861. HALL; Journ. Bost. Soc. Nat. Hist., p. 289.

1872. HALL; N. Y. State Museum Nat. Hist., Bull. I., Plate 2A, Figs. 12 and 13.

1881. W. and SP.; Revision Palæoc., Part II., p. 84.

Syn. *Dichocrinus pocillum* HALL, 1861; Journ. Bost. Soc. Nat. Hist., p. 291; figured Bull. I. N. Y. State Mus. Nat. Hist., Plate 2A, Figs. 16 and 17 (not 14 = *D. leviss*).

Larger than the two preceding species, the calyx more conical, the radials comparatively shorter. Calyx obconical, less rapidly spreading at the radials than along the basals. Plates thin; their surface smooth or finely corrugated.

Basal cup nearly one half the height of the calyx to the arm bases; column facet small, circular, slightly projecting. Radials a little wider than long, narrowest at the lower end, the upper face but little sloping at the sides; somewhat elevated longitudinally in the middle, forming an obscure ridge, which disappears before reaching the basals; facets semi-circular, narrow, occupying less than one-third the width of the plates at the top. Costals small, bending outward; the first very short, linear; the second depressed pentagonal, sharply angular at the top. Distichals divergent, as long as wide, and almost as wide as the costals; the second one axillary,

supporting two arms from each division, or four to the ray. Arms divergent, long and rather slender; composed of moderately long cuneate pieces, which gradually interlock, and from about the eighth plate are strictly biserial. Anal plate narrower than the radials, its sides almost parallel. Form and position of the anus unknown. Column round and small.

Horizon and Locality.—Upper and Lower Burlington limestone; Burlington, Iowa.

The specimens figured are in the collection of Wachsmuth and Springer.

Remarks.—Hall's *D. pocillum*, Bull. I. N. Y. State Museum, Plate 2A, Figs. 16 and 17, is a large example of this species, and his figure 14 on the same plate is probably *D. levis*.

***Dichocrinus angustus* WHITE.**

Plate LXXVI. Fig. 11.

1862. WHITE; Proceed. Bost. Soc. Nat. Hist., p. 19.

1881. W. and SP.; Revision Palæocr., Part II., p. 83.

A small and slender species. Calyx nearly twice as high as wide; sub-ovoid; very little spreading above the basals, the upper end slightly contracting. Plates without ornamentation or convexity beyond their general curvature. Suture lines not grooved or indented.

Basals forming a cup with rounded sides; the face for the attachment of the column not protuberant; it is circular and proportionally larger than in the preceding species. Radials almost twice as long as their width at the basi-radial suture; facets wide, but shallow, and pointing upward. Costals two, forming a syzygy, each plate marked by two small nodes. Distichals three; the two lower, which form a second syzygy, together but little larger than the third, or axillary. Arms four to the ray, composed of a single row of slightly wedge-shaped plates. Pinnules long. Anal plate a little wider below than at the top. All other parts unknown.

Horizon and Locality.—Upper Burlington limestone; near Burlington, Iowa.

Types in the Museum of Comparative Zoölogy.

Remarks.—This species is so closely allied to *D. levis* Hall from the Lower Burlington limestone, that there is reason to doubt whether it is a good species; however, as a rule, the specimens from the upper bed are smaller, the arm plates less cuneate, and there are, so far as observed, always four arms to the ray, which are invariably given off from the third distichal.

Dichocrinus crassitestus WHITE.*Plate LXXVI. Figs. 6a, b, c.*1862. WHITE; *Proceed. Bost. Soc. Nat. Hist.*, p. 19.1881. W. and SP.; *Revision, Palæocr.*, Part II., p. 83.

Of moderate size. Calyx up to the arm bases once and a half as high as wide; cylindrical along the radials, obconical below; the posterior side extended into a short conical tube, supported by the large anal plate; ventral disk depressed-convex; plates perfectly smooth; the suture lines rather obscure.

Basal cup fully one third the length of the calyx; conical, the sides straight, the lower end sufficiently truncated to form the columnar attachment. Radials twice as long as wide, the sides parallel or nearly so, the lower margins convex (at the anterior plate obtusely angular); the upper faces excavated to three fourths their width, slightly sloping at the ends. Costals two, linear, their combined length less than their width, and so closely anchylosed that the lines of union are seen with difficulty; upper face of the second plate very obtusely angular. Distichals 2×10 , nearly one half narrower than the costals, equally short, and anchylosed in a similar manner. Arms four to the ray, rather delicate, twice as long as the calyx; composed throughout of a single series of short joints, united by parallel sutures. Pinnules of moderate size. Anal plate of the same width as the radials, but considerably longer; its lower face distinctly angular, the upper truncated, slightly sloping to the sides, and supported by three medium-sized plates, which form the base of an anal tube. The tube is rather short, conical, placed at the margin of the disk, but bending inward to a position between the arms. The plates of the interradian series are not numerous; the three in contact with the radials are followed by two interambulacra, and these by a third. Column small, composed of circular joints, which increase in length downward, the nodal joints longest and widest.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Type in the Museum of Comparative Zoölogy.

Remarks. — This species differs from all others heretofore described in the form of the costals and distichals, and in having an anal tube.

Dichocrinus conus MEEK and WORTHEN.*Plate LXXV. Fig. 6.*

1860. MEEK and WORTHEN; *Proceed. Acad. Nat. Sci. Phila.*, p. 381; and *Geol. Rep. Illinois*, Vol. II., p. 169, Plate 16, Figs. 5a, b.

1881. W. and Sp.; *Revision Palæocr.*, Part II., p. 83.

Large for this genus. Calyx obconical; width and length as four to five; constricted at the upper end; distinctly hexagonal in outline, a keel-like angularity proceeding from the radial facet all the way to the lower end of the basals. Plates thin, without ornamentation, and united by closely fitting linear sutures.

Basal cup obconical, nearly as high as the radials, the sides perfectly straight; the basal concavity unusually small, being not larger than the width of the column; the re-entering angles at the upper face deep. Radials varying in size, their length from once and a half to twice their width, the antero-lateral ones wider than the others, but all increasing in width upwards; facets surrounded by a thickened angular rim, occupying nearly one third the width of the plates, and extending down to about one fifth their length, forming large limbs at the sides, which bend decidedly inward. Anal plate narrower than the radials, hexangular, fully twice as long as wide; the sides nearly parallel. All other parts of the species unknown.

Horizon and Locality. — Lower Burlington limestone; Burlington, Iowa.

Type in the Illinois State collection, Springfield.

Remarks. — Differing from all other species in the larger size, the angularities which extend to the whole length of the cup, the constriction of the cup at the upper end, and the great depth of the radial facets, with well defined limbs at the sides.

Dichocrinus inornatus W. and Sp.*Plate LXXVII. Figs. 12a, b.*

1890. W. and Sp.; *Geol. Rep. Illinois*, Vol. VIII., p. 190, Plate 16, Figs. 1 and 2.

Not above medium size. Calyx subovoid; the sides uniformly curving from the column to the arm bases; the ventral disk almost flat. Surface of plates devoid of ornamentation or other markings, except a faint longitudinal angularity along the middle of the radials.

Basals large, occupying fully one third the height of the calyx, and forming a rounded cup with obtuse angles upon the upper face; the column facet circular and slightly projecting. Radials one quarter to one half longer than wide, a little contracted at their lower ends, somewhat bulging at the middle portions, and abruptly inflected at the upper; facets less than half the width of the plates. Anal piece about the size of the radials, but narrower at the top and more distinctly bulging. Costals two, small; the first quadrangular, twice as wide as long; the second a little larger and triangular, the upper angle rather sharply pointed and bending inward, its sloping sides concave. The line of union between the two costals, compared with those above and below, quite obscure, constituting a syzygy, the epizygal joint supporting an arm. A second syzygy unites the two proximal arm plates, with a pinnule given off from the second. Arms two to the ray, twice or three times as long as the calyx, comparatively stout, tapering to the tips, and biserial from the third plate up. Arm plates of moderate length, with faces transversely parallel; the two series united by a zigzag suture. Pinnules extremely long, rather stout and closely packed; they are composed of from ten to fourteen joints, about three times as long as wide. Plates of the regular interradiial series three and two, all forming a part of the ventral disk. The anal side has five plates in the lower range. Orals arranged in the usual way; the posterior one largest and pushed in between the other four. They form a slight elevation, from which six well defined ridges pass out to the margin, five of them ambulacral, which divide and follow the arms; the sixth connects with the anus; the ambulacral ridges are composed of two rows of irregular pieces. The column in several perfect specimens averages eight to nine inches in length; it terminates in a fine point, and gives off at intervals, one by one, short cirri. All stem joints, except close to the calyx, are of equal length, and the older or nodal joints cannot be distinguished from the intervening younger ones. Axial canal minute.

Horizon and Locality. — Kinderhook group; Le Grand, Marshall Co., Iowa, where it is one of the most abundant species.

Types in the collection of Wachsmuth and Springer.

Dichocrinus Ulrichi MILLER and GURLEY.

1890. Journ. Cincin. Soc. Nat. Hist., Vol. XIII. (Author's Ed., p. 48), Plate 8, Figs. 12 and 13.

A small species. Calyx subovoid, once and a half as high as wide, somewhat constricted at the upper end, pointed at the lower; the plates smooth. Basals large, forming a high obconical cup, with a deep notch at the anal side; the column facet small. Radials nearly twice as long as wide, spreading upwards, reaching their greatest width at three fourths their height, contracting at the upper end; the sides slightly depressed, leaving the sutures rather distinct; facets narrow, and occupying but one third the width of the radials. Costals two, apparently united by syzygy, as well as the two proximal distichals, both being so closely united that the lines are frequently invisible. Arms two to the ray, rather long and comparatively stout; they are composed of single joints, of which the upper and lower edges are almost parallel, and not so decidedly cuneate as figured by Miller and Gurley. Pinnules coarse, long, and closely packed. First interbrachial plates visible in a side view. Anal plate a little longer and narrower than the radials.

Horizon and Locality. — Upper part of the Keokuk group; Bono, Lawrence Co., Ind.

Type in the collection of Wm. F. E. Gurley.

Remarks. — This species resembles so closely *Dichocrinus scitulus* from the Upper Burlington limestone, that we doubt if the two forms represent different species. We find it impossible to separate them in our collection, in which we have specimens from both horizons.

Dichocrinus Hamiltonensis WORTHEN.

Plate LXXVI. Fig. 10.

1882. Bulletin I., Illinois State Museum Nat. History, p. 35.

1883. Geol. Rep. Illinois, Vol. VII., p. 313, Plate 27, Fig. 10.

A little larger than the preceding species. The specimen from which the description was made, and the only one known to us, is badly crushed, and the exact proportions of the calyx cannot be given. From its appearance, however, we take the length of the dorsal cup to be about equal to its width, and the height of the basals about half that of the radials. The latter are subquadrangular, narrower at the lower end, the length equal to their

greatest width, the sides straight, the facet for the reception of the costals narrow and but slightly excavated. Costals two, apparently followed by a single distichal, no line of division being visible in the specimen. Arms four to the ray; of medium length, rather strong, and composed of long, cuneate plates, which slightly interlock. Pinnules stout, long, and not in contact. Anal plate narrower than the radials, but longer and rather distinctly angular at the lower end. Structure of the ventral disk unknown. Plates of the calyx without ornamentation.

Horizon and Locality.—Upper part of Keokuk group; Hamilton, Ills.

Remarks.—Professor Worthen described this species as having probably two arms to the ray, which is certainly incorrect. It is clearly shown from the type specimen in the collection of Mr. Lisbon A. Cox, which we have figured, that it has four arms, and but two costals followed by a distichal, instead of three costals, as he supposed.

Dichocrinus Huntsvillæ W. and Sp. (nov. spec.).

Plate LXXV. Fig. 4.

Syn. *Platycrinus parvulus* MEEK and WORTHEN; 1865, Geol. Rep. Illinois, Vol. V., p. 555, Plate 20, Fig. 7.

Of very small size. Dorsal cup gradually spreading to the top of the basals, the sides along the radials almost parallel. Plates delicate and perfectly smooth, the suture lines indistinct. Basals forming an obconical cup, of which the height is equal to two fifths the length of the calyx to the arm bases. Radials twice as long as wide; the two posterior ones considerably wider above than below, the sides of the three anterior ones almost parallel; the upper faces nearly straight, their median portions but slightly excavated, and the sides but little sloping. The anal plate narrower at the top than the radials, but wider at the lower end. Costals two, more than twice as wide as long and about half the width of the radials; the upper faces of the axillary somewhat concave. Distichals two, frequently as large as the costals, the first sometimes a little narrower. Arms four to the ray, small, rounded on the back. They are composed of a few transverse single pieces, followed by cuneate ones, which gradually interlock, but the smaller ends do not reach the sides of the arm. Pinnules long and stout. Structure of ventral disk not known.

Horizon and Locality.—St. Louis group; Huntsville and Whitesburg, Ala. *Types* in the collection of Wachsmuth and Springer.

Dichocrinus pendens W. and Sp. (nov. spec.).*Plate LXXVIII. Fig. 15.*

Of medium size. Calyx apparently subovoid, a little higher than wide; the plates very delicate and without ornamentation; the suture lines not grooved; the arms pendent.

Basal cup bowl-shaped, the plates a little shorter than the radials. Radials nearly once and a half as wide as long, widest at one third their height, the sides being distinctly convex; radial facets directed upwards, rather shallow, but wide, and occupying four fifths the width of the plates at the upper end. Costals two, short, the upper wider than the lower. Distichals two, axillary, giving off four arms to the ray. The arms from the fourth or fifth palmars curve abruptly downward in such a manner as to envelope the calyx and the upper part of the stem, exposing the ventral furrows of arms and pinnules. Arms ten, biserial at the upper ends, the lower arm joints cuneate, alternately arranged. Pinnules stout, long, and flattened. Column round; the nodal joints wider and longer than the internodals, the latter, so far as observed, consisting of a single ossicle to the internode.

Horizon and Locality. — Upper Burlington limestone; Burlington, Iowa.

Types in the collection of Wachsmuth and Springer.

Remarks. — Distinguished from all preceding species by the pendent arms, which is a constant feature in half a dozen specimens.

Dichocrinus ficus CASS. and LYON.*Plate LXXVIII. Figs. 16a, b.*

1860. CASSEDAY and LYON; Proceed. Amer. Acad. Arts and Sci., Vol. V., p. 24.

1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 502, Plate 14, Figs. 5a, b (not ibid., Vol. VI., Plate 29, Fig. 7).

1881. W. and Sp.; Revision Palæocr. Part II., p. 83.

A small and very slender species. Calyx ovate, twice as long as wide, widest near the middle of the radials, whence it curves gradually and evenly to the end of the basals, and somewhat more rapidly to the arm bases. Plates smooth, without markings, except a small angularity following up and down the median portions of the radials.

Basals formed into a deep, obconical cup, about as high as wide; only truncated for the reception of the column, the lower face slightly concave.

Radials once and a half as long as wide, widest across the middle; the upper faces deeply excavated to more than one half the width of the plates. Costals two, closely anchylosed and very short, their combined length less than their width; the lower plate, and partly the upper, resting completely within the facet, the distal faces of the upper but slightly angular. Distichals three; the two lower plates so closely anchylosed that the suture line is frequently obsolete. The costals and distichals, in place of taking the usual outward curve, bend slightly inward, so as to make the width of the specimen directly above the radials less than the width of the cup. Arms twenty (not twelve, as stated by Casseday and Lyon), closely folded at their proximal ends, recurving above the second bifurcation, and the tips hanging downward, exposing the ambulacra. Pinnules long. Anal plate of the same width as the radials, but the lower margin distinctly angular, and the upper concave; it is followed by numerous small plates forming a small, rounded protuberance. Position of the anus almost marginal. Column round.

Horizon and Locality. — Keokuk limestone; Crawfordsville, Ind., and Hardin Co., Ky.

Types in the collection of the late Major Lyon at Jeffersonville, Ind.

Remarks. — The specimen which Professor Worthen erroneously figured in the Illinois Geol. Report of 1876 under this name has but ten arms, while *D. ficus* has twenty. Besides, it differs quite essentially in the form of the calyx. Curiously enough, Worthen described his specimen as having five radials and six costals, evidently supposing, as Casseday and Lyon did, that the anal plate supported two arms.

This species approaches *D. pendens* in its tendency to pendent arms; but the latter is larger, the dorsal cup proportionally wider, the baso shorter, and bowl-shaped instead of obconical.

***Dichocrinus pentalobus* (CASS. and LYON).**

Plate LXXVIII. Figs. 11a, b, c.

1860. *Cotyledonocrinus pentalobus* — CASSEDAY and LYON; Proceed. Amer. Acad. of Arts and Sci., Vol. V., p. 26.

1865. (?) *Cotyledonocrinus pentalobus* — SHUMARD; Catal. Palæoz. Foss. N. Amer., p. 360.

1877. *Cotyledonocrinus pentalobus* — S. A. MILLER; Catal. Amer. Palæoz., Foss., p. 92.

1881. (?) *Cotyledonocrinus pentalobus* — Revision Palæocr., Part II., p. 78.

Calyx elongate; plates thin and without ornamentation. Basals large, forming a sub-ovoid cup with a thickened rim around the lower margin; bottom but partly occupied by the column. Radials gradually increasing in

width, widest at two thirds their height; slightly contracted at the top and twice as long as their width at the bottom; the outer surface a little convex, and somewhat angular along the median line; facets deeply excavated to almost the full width of the plate, leaving a slight truncation at each side. Costals and distichals two each, united by syzygy, their combined length about equal to the width; both costals and the lower distichal completely resting within the radial facet. Lines of union between the hypozygal and epizygal joints straight, but those between the costals and distichals, and between the distichals and palmars, decidedly waving and much more distinct. The upper faces of the epizygal joints provided with tongue-like processes, which enter corresponding recesses upon the lower faces of the plates of the succeeding order. First palmar deeply excavated along the upper face, and constituting a part of the calyx; the succeeding ones are free arm plates, and bend abruptly outward. Arms twenty, strong, simple, biserial and pendent, resting by their dorsal surfaces upon the radials and anal plate, which are slightly impressed thereby. Pinnules stout and long; their ambulacral furrows wide, and roofed over by small covering plates. Ventral disk slightly convex, almost flat, the ambulacra exposed to view. Four of the interradii have but one plate in contact with the radials, while the anal plate supports three, the former as well as the latter abutting against the second distichals, but not against the first, nor against the costals, which rest within the radial facet. Anal opening subcentral, passing through the flat surface of the disk. Column round and small.

Horizon and Locality. — Kaskaskia group; Grayson Springs, Grayson Co., Ky., and Sloans Valley, Pulaski Co., Ky.

Types in the Major Lyon collection, Jeffersonville, Ind.

Remarks. — A strict enforcement of the rules of nomenclature would, according to some opinions, require the above specific name to be rejected on account of erroneous composition. After being so long recognized in scientific literature we prefer not to change it, — at least not until greater necessity appears for doing so.

Dichocrinus dichotomus HALL.

1859. HALL; Suppl. Geol. Rep. Iowa, p. 85 (diagram Plate 1, Fig. 5).

1881. W. and SP.; Revision, Palæocr., Part II., p. 83.

According to Hall, the calyx is shallow cup-form, the basals occupying one third its height. Radials wider than long, the lower margin of the facet slightly thickened. Costals extremely short and narrow, occupying scarcely the fifth part of the width of the radials at the top. Arms dichotomizing twice or oftener, uniserial in the lower portions; composed of cuneate plates, which gradually interlock upward. Surface of plates "punctate or marked by slight rounded depressions, separated by narrow, elevated lines."

Horizon and Locality. — Warsaw limestone, Warsaw, Ill.

Remarks. — This species was described from a crushed specimen in the collection of the late Professor Worthen, from which the characters cannot be satisfactorily ascertained.

Dichocrinus Humburgi S. A. MILLER.

1891. S. A. MILLER; Geol. Surv. Missouri, Bull. 4, p. 26, Plate 3, Figs. 9 and 10, and Adv. Sheets 17th Rep. Geol. Surv. Indiana, p. 36, Plate 6, Fig. 38.

Described from two specimens, which are only preserved to the second palmars, and, according to Miller, "show considerable variation in size and relative proportions," the radials of the one "only about one half longer than wide," in the other "twice as long as wide." Basal cup a little less than half the length of the calyx, obconical, truncated, and slightly concave at the bottom, the column not filling the lower concavity, the re-entering angles "hardly discernible on either side." Radials expanding but little, the facets occupying nearly the entire width of the plates. Costals "one," thin and axillary. Distichals two. Arms twenty, uniserial so far as observed. Anal plate a very little smaller than the radials, the upper end contracting. Surface of plates smooth.

Horizon and Locality. — Lower part of Warsaw limestone; Boonville, Mo.

Type in the collection of Mr. R. A. Blair, of Sedalia, Mo.

Remarks. — The two specimens alluded to above not only differ in the proportions of the plates, but also the re-entering angles meeting the basi-radial suture, which in the one were said to be "hardly discernible," are in the other, according to figure, unusually deep. The specimens evidently

have two costals, as all other *Dichocrini*, and Miller overlooked the syzygial suture, which is often quite obscure in this genus. This form should be compared with *D. ficus*, with which it is probably synonymous.

***Dichocrinus parvulus* S. A. MILLER.**

1891. S. A. MILLER; Geol. Surv. Missouri, Bull. 4, p. 27, Plate 4, Figs. 7, 8.

Calyx small. Dorsal cup higher than wide, somewhat obconical; sutures slightly depressed, giving a little convexity to the plates; surface granular. Basals forming a short obconical cup, twice as wide as high, pointed to the small column below; the re-entering angles toward the basi-radial suture deeper at the posterior side than at the anterior. Radials one half longer than wide; their width increasing upwards; the facet broad and but slightly excavated. Costals one — according to Miller, but probably two — a little wider than long, and occupying three fourths of the width of the radials. Arms ten, rounded on the back, and composed of a single series of short cuneate pieces. Pinnules heavy and closely packed. Anal plate a little narrower than the radials. Column round.

Horizon and Locality. — Lower part of Warsaw limestone; Boonville, Mo.
Type in the collection of Mr. R. A. Blair, Sedalia.

***Dichocrinus Blairi* S. A. MILLER.**

Plate LXXV. Fig. 3.

1891. S. A. MILLER; Adv. Sheets 17th Rep. Geol. Surv. Indiana, p. 36, Plate 8, Fig. 12.

Calyx short, obconoidal or subturbinate; plates thin; surface granular. Basal cup a little more than one third the length of the calyx to the top of the radials; the re-entering angles rather deep. Radials slightly expanding, twice as long as wide, longitudinally convex, and projecting at the facets, which occupy half the width of the plates, and slope downward. Costals two, supporting 2×2 distichals, which apparently are free from the costal axillary. Arms four to the ray, large, long, and composed of a single series of short, cuneiform pieces. Pinnules long and heavy. Column round, composed of short pieces; the nodal ones somewhat projecting.

Horizon and Locality. — Same as last.

Type in the collection of Mr. R. A. Blair.

Remarks. — The calyx of the type specimen is much flattened, and it is

difficult to make comparison with allied forms. The descriptions of this and the two preceding species are made after Miller, we having no authentic specimens for comparison.

CAMPTOCRINUS W. and SP. (nov. subgen.).

(καμπτός pliant, κρίνον a lily.)

In the construction of the calyx and arms identical with *Dichocrinus*, but differing in the structure of the stem, which in all the specimens in which we observed it is curled around the crown. The stem joints are circular near the calyx, but at some distance off gradually turn into crescent-shaped, and the two horns of the crescent give off long, stout, and pliant cirri from every joint. The stem coils to the concave side.

The structure of this stem reminds us of Hall's genus *Myelodactylus* * of the Niagara group; and similar stems occur in the Wenlock limestone of Dudley, England, and Gotland, Sweden, which have been referred by Angelin, and also by Bather, to the inadunate genus *Herpetocrinus* Salter, a genus with close affinities to *Heterocrinus*. Such stems are also found among the *Poteriocrinidæ* of the Kaskaskia group, showing that they occur not only at various horizons, but also in very different groups; and we doubt if this structure is of much importance for classification. We therefore place *Campocrinus* subgenerically under *Dichocrinus*.

Distribution.—Found from the Keokuk limestone to the Kaskaskia group, and apparently restricted to America.

Type.—*Campocrinus myelodactylus*.

Campocrinus myelodactylus W. and SP. (nov. spec.).

Plate LXXV. Figs. 1, 2a, b.

A small species with curving stem and long paired cirri, which are given off in longitudinal rows on the concave side, as in Hall's *Myelodactylus*. Calyx elongate, slightly spreading; the plates smooth; the suture lines indistinct. Base one third the height of the dorsal cup, its sides convex. Radials twice as long as wide; the facets not excavated, and the costals resting upon the straight upper faces, occupying three fourths their width. Costals two, very short; the second obtusely angular above. Arms two to the ray, in close contact laterally, twice and a half as long as the calyx, and composed of

* Palæont. N. York, Vol. II., p. 232, Plate 42, Figs. 5, 6, and Plate 45, Figs. 7, 8, 9.

rather long quadrangular pieces. Pinnules long. Anal plate in size and form resembling the radials. Anus and ventral disk not visible in the specimens.

Column near the calyx straight, but at 5 mm. from the calyx it curves abruptly back upon the crown, then it enlarges, and by a reverse curve coils upon itself and the included calyx and arms, giving off from alternate joints at the concave side two rows of long cirri, which sometimes completely envelope and conceal the crown. Near the calyx, the stem joints are short and circular, but they gradually grow longer and crescent-shaped, their width increasing from 2 to 3 mm. The cirri are very long and stout at their proximal ends, but terminate in a sharp point. They are composed of about sixteen to eighteen joints, which are as wide as long, and radiate from the centre of the spiral curvature of the stem.

Horizon and Locality. — Keokuk group; Indian creek, Montgomery Co., Ind.

Types in the collection of Wachsmuth and Springer.

Camptocrinus cirrifer W. and Sp. (nov. spec.).

Plate LXXVI. Figs. 13a, b, c.

In its general aspect closely resembling the preceding species, the calyx, however, shorter, especially the basal part, which occupies only one third the length of the dorsal cup, being but slightly convex at the bottom, and rather deeply depressed in the centre for the reception of the column. Radials once and a half as long as wide, the sides nearly parallel, the upper faces slightly excavated to one half their width. Costals two, very short, the intervening suture lines obscure; the first linear, the second subtrigonal, its sloping upper faces at right angles. Arms two to the ray, simple, slender, divergent, thread-like in the upper portions, and composed of long, quadrangular joints. Pinnules of moderate length and not in contact. All plates perfectly smooth. Structure of ventral disk and anus unknown.

The column is narrow in the upper portions, but gradually increases in width downward, until at an inch and a half from the basals it is twice as wide as at the top. Close to the calyx it bends abruptly upward to a level with the top of the radials, then reversing it curves downward, either gently to the end, or — more generally — forming a coil around the crown. The stem joints are short and circular near the calyx, but soon grow longer, and the section becomes oval and gradually crescent-shaped with the concave

side inward. Both horns of the crescent give off cirri from alternate plates, communicating with the axial canal of the stem, which is oval, its long diameter at right angles to the curvature of the column. There are no cirri in the upper part of the stem; they commence at some distance from the calyx, and are restricted to the convoluted part. In specimens with a closely coiled stem, the ends of the cirri meet in the centre, and resemble the spokes of a wheel; they are stout at the proximal end and extremely long, being composed of thirty or more pieces, of which the five proximal ones are longer than wide, the upper somewhat shorter.

Horizon and Locality. — Kaskaskia group, near Sloans Valley, Pulaski Co., Ky.

Types in the collection of Wachsmuth and Springer.

TALAROCRINUS W. and SP.

1881. W. and SP.; Revision Palæocr., Part II., p. 85 (Proceed. Acad. Nat. Sci. Phila., p. 259).
 1883. S. A. MILLER; Catal. Amer. Palæoz. Foss. (Second Edit.), 288.
 1885. W. and SP.; Revision Palæocr., Part III., p. 120 (Proceed. Acad. Nat. Sci. Phila., p. 342).
 1889. S. A. MILLER; N. Amer. Geol. and Palæont., p. 285.
 Syn. *Dichocrinus* (in part) — SHUMARD; Trans. St. Louis Acad. Sci., Vol. I., p. 71.
 Syn. *Dichocrinus* (in part) — CASS. and LYON; Proceed. Amer. Acad. Arts and Sci., pp. 16-23.
 Syn. *Pterotocrinus* (in part) — S. A. MILLER; Catal. Amer. Palæoz. Foss. (First Edit.), p. 89.

Specimens small. Calyx, as a rule, higher than wide; the ventral disk as high as the dorsal cup; the plates thick and devoid of ornamentation.

Basals two, of equal size and similar form, the suture between them passing from the anal plate to the anterior radial; they form together a shallow cup, which is more or less transversely elongate, and somewhat excavated at the bottom; the superior margin of the cup octagonal, six angles being salient and two retreating, the latter directed to the sides which correspond to the longer diameter of the base.

Radials five, enclosing an anal plate of the same size or even larger; four of them having slightly convex lower faces; while the anterior one is angular below. The upper faces are somewhat excavated in the middle, and truncated at the outer ends. Costals one, very small, often completely hidden from view by the distichals; when visible, triangular in outline. Distichals one or two, small; their lower faces resting obliquely against the costals; their sides touching the radials. The third order of brachials supports the free arms, of which there are four to the ray. The arms, so far as observed, are simple and biserial.

Interradials one or three in the first row, followed by one or two in the second, all forming a part of the ventral disk. The large anal plate of the dorsal cup is generally followed at the tegmen by two rows of three plates each, and these by a large number of minute pieces, which enclose the anus. The anal opening is directed laterally and placed near the upper end of the anal area. The posterior oral occupies a central — or nearly central — position; it is highly protuberant, and very large compared with the other four, which are small, scarcely convex, and pushed to the anterior side; but sometimes they may be unrepresented altogether. In this case, small covering pieces follow the sides of the posterior oral; but when all the orals are represented, generally large radial dome plates of a first and second order take the place of the covering plates.

Column round, small; axial canal minute.

Distribution. — Probably restricted to the age of the Warsaw and St. Louis groups.

Type of the genus: *Talarocrinus cornigerus* (Shumard).

Remarks. — *Talarocrinus* forms a transition between *Dichocrinus* and *Pterotocrinus*. It preceded *Pterotocrinus* in geological time, while *Dichocrinus*, although surviving *Talarocrinus*, reached its climax before the latter was introduced. The species upon which the genus was founded were originally described by Shumard and Casseday and Lyon under *Dichocrinus*, whence S. A. Miller removed them to *Pterotocrinus*.

Talarocrinus differs from *Dichocrinus* in the more massive plates, and in having but one costal to the ray. The latter is the case also in *Pterotocrinus*, but the distichals in that genus are comparatively large, and form an important part of the calyx; while those of *Talarocrinus* are small, and retain the form of free arm plates. Besides, *Pterotocrinus* has large, wing-like appendages fastened to the surface of the test, like which nothing is found in *Talarocrinus*; the corresponding plates of the latter are much smaller and are inserted between the other plates, instead of resting against their beveled outer edges.

Talarocrinus cornigerus (SHUM.).*Plate LXXVIII. Figs. 6a, b, and 7a, b.*

1856. *Dichocrinus cornigerus* — SHUMARD; Trans. St. Louis Acad. Sci., Vol. I., p. 72, Plate 1, Figs. 1a-d.
 1865. *Pterotocrinus cornigerus* — SHUMARD; Catal. Palæoz. Foss. N. Amer., p. 393.
 1877. *Pterotocrinus cornigerus* — S. A. MILLER; Catal. Amer. Palæoz. Foss. (1st Edit.), p. 89.
 1881. *Talarocrinus cornigerus* — W. and S.; Revision Palæocr., Part II., p. 87.
 1883. *Talarocrinus cornigerus* — S. A. MILLER; Catal. Amer. Palæoz. Foss. (2d Edit.), p. 288.

Calyx ovate, the base slightly truncated and excavated at the bottom. Dorsal cup a little lower than the ventral disk, and somewhat shorter than wide; the plates strong, moderately convex, but without other markings; suture lines distinctly grooved.

Basals forming a shallow cup, which is transversely elongated, and occupies about one third the height of the dorsal cup; it is concave at the lower face, and the cavity is only partly filled by the column. Radials sub-quadrangular, slightly increasing in width upward, their length equal to the greatest width; the plates are a little tumid, the greatest convexity being at two thirds their height, whence they slope considerably to the upper margin, producing a moderate depression or constriction beneath the arm regions. Anal plate considerably longer than the radials, its upper face on a level with the top of the distichals, its lower face angular, the lateral faces parallel. Costals and distichals very small, the former trigonal, often not visible externally, and the distichals appear as if they rested upon the radials, as described by Shumard; they bend slightly outward, and are wider than high, their upper faces concave, forming a sharp angle. First palmars narrower and shorter than the distichals, rounded like arm plates; the two outer ones touching the radials. Arm openings four to the ray. The arms are not preserved in any of the specimens. Ventral disk highly elevated and bulging; the interambulacral spaces depressed, and the plates flat. The radial dome plates strongly tuberculous, the other disk plates convex. Posterior oral strictly central and of extreme size, forming a large ovate tubercle, the shorter diameter facing the posterior and anterior sides. The other orals quite small and scarcely convex. Four of the interambulacral spaces narrow, and the plates elongate; arranged 1, 2, 2, with sometimes one or two small accessory pieces interposed between them. The posterior interradius is wide, being composed above the anal plate

of four or five moderate sized plates, followed by a very large number of small pieces, forming an elongate, convex area, which rises from the large anal plate, and extends to the posterior oral, being surrounded on all sides by a shallow groove. The plates of the area, although irregular in form, are arranged with a certain regularity, and the lower ones are considerably larger than those surrounding the anal opening, which are very minute. The anus is located in the upper part of the area, and opens out laterally. Column small and round.

Horizon and Locality. — Upper part of St. Louis group; Franklin Co., Ala., and Tateville, Pulaski Co., Ky.

Type in the Shumard collection at the Museum of Washington University, St. Louis.

***Talarocrinus sexlobatus* (SHUM.).**

Plate LXXVIII. Figs. 1a, b, c.

1856. *Dichocrinus sexlobatus* — SHUMARD; Trans. St. Louis Acad. Sci., Vol. I., p. 73, Figs. 3, 3a-c.
 1865. *Pterotocrinus sexlobatus* — SHUMARD; Catal. Palæoz. Foss. N. Amer. p. 394.
 1867. *Pterotocrinus sexlobatus* — S. A. MILLER; Catal. Amer. Palæoz. Foss. (1st Edit.), p. 89.
 1881. *Talarocrinus sexlobatus* — W. and SP.; Revision Palæocr., Part II., p. 87.
 1883. *Talarocrinus sexlobatus* — S. A. MILLER; Catal. Amer. Palæoz. Foss. (2d Edit.), p. 288.

Calyx a little higher than wide, constricted at the arm regions, and surmounted by five short heavy spines. Dorsal cup more depressed than in the preceding species, the plates more rapidly spreading and more tumid, making the outline of the cup, as seen from below, quite distinctly six-lobed. The plates devoid of ornamentation.

Basal cup shallow, its height from a side view less than one fourth the length of the radials; the salient angles at the upper margin very obtuse, as are also the re-entering angles toward the anal plate and anterior radial; the centre slightly excavated for the reception of the column. Radials about as wide as long, widest at two thirds their height, very thick and tumid in the middle; their greatest convexity is near the upper end, whence they slope rapidly to the arm bases, forming a rounded, transverse node. The lower faces in four of the radials are straight, or nearly so, in the anterior one obtusely angular; all the superior faces are deeply excavated, and their outer ends project somewhat like the limbs of the radials in Blastoids. The anal plate is longer than the radials, and, like them, tumid near the top and widest across the middle. Costals very small, not visible externally, being perfectly covered by the distichals. Distichals comparatively large, resting

completely within the radial facets; wider than long, sharply angular at the top, their sloping upper faces concave. Arms four to the ray, their structure unknown. Ventral disk highly elevated, resting upon the inflected upper ends of the radials and anal plate, and hence narrower than the dorsal cup; the sides almost vertical, and the summit flat. The posterior oral, which is subcentral, is large and strongly convex, the four others considerably narrower and almost flat; the outer ends of the latter curve abruptly downward, and take part in the sides of the disk. The radial dome plates rest at right angles between two orals; they are quite large, and are extended into short, heavy obliquely directed spines. The first range of interradians consists of three pieces, of which the two outer ones are very narrow and do not touch the radials; they are followed by two small interambulacra, and these by the orals. The anal plate supports upon its truncate upper face a rather large quadrangular piece, and upon its upper sloping faces an elongate narrow one, followed by other rows of three plates of smaller size, and by a moderate number of other pieces, which form a small protuberance containing the anus. Anal opening on a level with the posterior radial dome plates.

Horizon and Locality.—Upper part of St. Louis group; Russellville, Ky.; Logan Co., Ky., and Flagpont, Va.

The *type* specimen, formerly in Dr. Shumard's collection, could not be found in the Museum of Washington University at St. Louis, and is probably lost. The specimens figured are from the collection of Wachsmuth and Springer.

Remarks.—This species is readily distinguished from *T. cornigerus* by the greater depression and tumidity of the dorsal cup, the constriction at the arm bases, the erect form of the disk, the narrowness of the anal interradius, and the comparatively small number of disk plates.

Talarocrinus symmetricus CASS. and LYON.*Plate LXXVIII. Figs. 4a, b, and 5.*

1860. *Dichocrinus symmetricus* — CASSEDAY and LYON; Proceed. Amer. Acad. Arts and Sci., Vol. V., p. 21.
 1866. *Dichocrinus symmetricus* — SHUMARD; Catal. Palæoz. Foss. N. Amer., p. 367.
 1877. *Dichocrinus symmetricus* — S. A. MILLER; Catal. Palæoz. Foss. Amer. (1st Edit.), p. 76.
 1881. *Talarocrinus symmetricus* — W. and SP.; Revision Palæocr., Part II., p. 87.
 1883. *Talarocrinus symmetricus* — S. A. MILLER; Catal. Pal. Foss. Amer. (2d Edit.), p. 283.
 Syn. *Dichocrinus elegans* — LYON and CASS.; Proceed. Amer. Acad. Arts and Sci., Vol. V., p. 22.
 Syn. *Talarocrinus elegans* — W. and SP.; Revision Palæocr., Part II., p. 87.

This species is closely allied to the preceding one, but somewhat smaller; the dorsal cup is more depressed, the form of the ventral disk more conical, less contracted at the periphery, and the anal area wider. Dorsal cup semi-globose, slightly lobed as seen from above or below, the plates without ornamentation; suture lines distinctly grooved.

Basal cup quite shallow, widest at right angles to the interbasal suture. Radials spreading rapidly to the middle, less rapidly in the upper portions; the superior faces a little excavated, and their outer edges slightly truncated. Anal plate longer than the radials, widest in the middle, the upper end inflected, making the lateral faces convex. Costals and distichals very small; not exposed upon the surface; they are hidden by the two inner palmars of the first row, which overlap them. The two outer palmars of the first row rest upon the radials, their lateral faces support an interbrachial, which also slightly touches the radials. Palmars four in the calyx, in contact laterally, short and rather deeply excavated for the reception of the higher brachials, which are not preserved in the specimens. The arms of the same ray are equidistant, while those of different rays are farther apart and separated by a shallow groove. Ventral disk higher than the dorsal cup. The interambulacral spaces filled by one and two narrow plates followed by the orals; the first radial dome plate is conical. The large anal plate supports three plates, of which the middle one is considerably wider than high and somewhat depressed, the two others quite narrow. The second row also consists of three pieces, and these are succeeded by numerous smaller ones, which form an elongate rounded ridge containing the anus. This ridge, which is bounded laterally by a shallow groove, extends to the posterior oral in an almost vertical line. The primary radial dome plates alternate with the orals; they are large and either spinous or strongly tuberculous. The secondary radial dome plates are elongate and enclose a large interdistichal.

Horizon and Locality. — Upper part of St. Louis limestone; Grayson, Edmondson, and Pulaski Cos., Ky.

Remarks. — The type specimen, which is figured on Plate LXXVIII., Fig. 5, is in the Lyon collection; that of Figs. 4*a*, *b* on the same plate is in the collection of Wachsmuth and Springer.

Dichocrinus elegans Cass. and Lyon, in our opinion, belongs to this species. The type specimen, which is badly crushed, is possibly a little more lobed at the ventral disk, but that alone is not sufficient to make it a different species. The differences to which the authors refer are not borne out by the facts. *Talarocrinus symmetricus*, like *T. elegans*, has four arms to the ray, and not two, as stated in the description.

***Talarocrinus ovatus* WORTHEN.**

*Plate LXXVIII. Figs. 2*a*, *b*.*

1882. WORTHEN; Bulletin I., Illinois State Mus. Nat. Hist., p. 36.

1883. WORTHEN; Geol. Rep. Illinois, Vol. VII., p. 314, Plate 29, Fig. 11.

1885. W. and Sp.; Revision Palæocr., Part III., p. 120.

Calyx more elongate than in the preceding species, ovate in its general outline, the dorsal cup proportionately higher and less spreading, the radials more evenly convex, and not tumid at the upper end. Basal cup comparatively large and deep, truncate at the bottom, and slightly excavated for the reception of the column; the sides but little expanding. Radials somewhat longer than wide, a little wider above than below, slightly inflected at the upper end; their lower faces straight, except at the anterior plate where they are distinctly angular; the upper deeply excavated to about one half their width, and the facet directed obliquely outward. Anal plate longer than the radials and heptagonal. The costals rest obliquely upon the radials, and are larger than usual in this genus, forming a small triangle with concave sides. Of the distichals only one row of plates is visible, which are short and excavated at the upper face. This may have been followed by an axillary distichal, or have directly supported the arms. The number and structure of the arms unknown. Ventral disk highly elevated, the interambulacral spaces depressed, especially near the arm bases. Anal area projecting, giving to the ventral disk, as seen from the summit, a distinctly hexagonal outline. Interradial plates three and one; the middle plate of the first range, and the upper, very large, the two at the sides small, about half as long as the middle one and considerably narrower. Anal area elon-

gate convex and bordered by a groove; it has three rather large plates in the first row, and three in the second, followed by a moderate number of smaller pieces; the opening is directed obliquely upward. Posterior oral twice the size of the other four and spinous, while the latter are slightly convex. Radial dome plates large and tuberculous. The arrangement of the other disk plates is similar to that of the preceding species.

Horizon and Locality. — (?) Kaskaskia group; Monroe Co., Ills.

The *type* and only known specimen is in the Illinois State collection.

Remarks. — Professor Worthen gives the horizon of this species as "Chester limestone," which probably should be changed into *upper* part of St. Louis group. We infer this from the preservation of the specimen, and the fact that all the other species come from that horizon.

Talarocrinus decornis W. and Sp. (nov. spec.).

Plate LXXVIII. Figs. 3a, b, c.

(?) Syn. *Dichocrinus constrictus* M. and W; 1869, Geol. Rep. Ills., p. 263, Vol. II., Plate 19, Figs. 2a, b, c.

Smaller than any of the preceding species. Calyx once and a half as wide as high, elliptical in outline, the arm bases projecting, the interradial spaces depressed. Dorsal cup higher than the ventral disk; the plates convex and without ornamentation; suture lines slightly grooved.

Basals large, forming a rounded cup, which, viewed in profile, has about half the height of the radials; lower face of the cup a little concave. Radials erect, a shade wider at the top than at the bottom, about as wide as long; their lower faces nearly straight, the upper excavated to one half their width at the middle, and the outer ends distinctly truncated for the reception of a small interbrachial. Anal plate a little longer than the anterior radial, the upper end somewhat inflected so as to form a well defined depression at the upper end. Distichals two; the lower one quite short, resting completely within the radial facets, and not coming in contact with the interbrachial plate. Second distichals much larger, sharply angular above, and directed slightly outward. The first palmars take part in the calyx; the others are free. Arms four to the ray, biserial above the third or fourth plate; they are rather stout, rounded on the back, and composed of moderately long, slightly convex pieces, which interlock by a zigzag suture line. Ventral disk highly convex; the summit surmounted by an immense nodose plate. Interambulacral spaces narrow, deeply depressed, having a single elongate plate

in the first row, which is followed by a smaller one. The anal interradius, which is much the widest, has one plate in the two proximal rows, followed by small pieces forming a little protuberance around the anus. Orals represented by a single piece, from the sides of which the covering plates of the ambulacra pass out to the arms; the plate is highly convex or nodose, and as large as the five orals in other species. Ambulacra projecting, the covering plates consisting of two rows of small pieces, which are alternately arranged; they bifurcate on a rather large axillary, and the two branches are separated by a large interdistichal.

Horizon and Locality. — Upper part of St. Louis group; Tateville, Pulaski Co., Ky.

Types in the collection of Wachsmuth and Springer.

Remarks. — This species is remarkable for having but a single oral plate; the other four orals are either undeveloped, or, more probably, were resorbed in the growing crinoid. Another peculiarity of this species is the absence of spines, and the presence of regular covering pieces in the disk.

Meek and Worthen's *Dichocrinus constrictus* may possibly be identical with this species, but as only the basals and radials are known no satisfactory comparison can be made.

***Talarocrinus subglobosus* W. and Sp. (nov. spec.).**

Plate LXXIX. Figs. 1a, b.

A small species. Calyx proportionally shorter than in *T. decornis*, and subglobose instead of ovate; the interradiial spaces depressed at the arm regions; plates of the dorsal cup rounded and a little convex; suture lines somewhat grooved.

Basal cup small and quite shallow; widest at right angles to the suture line; the lower face slightly excavated. Radials about as wide as long, rapidly spreading from the base upward, tumid, and a little inflected at the upper part; radial facets broadly excavated, and the limbs slightly truncated for the reception of the interbrachials. Anal plate larger than the radials and considerably widest across the middle. Costals quite large for the genus, filling almost the entire width of the facets in which they rest. Distichals 2×2 , short, those of the first range slightly touching the radials, and all, together with the costals, facing outward. Arms four to the ray, free above the distichals. Ventral disk subpyramidal, a little shorter than the dorsal

cup; the interradial spaces depressed and wider than usual in this genus; they are composed of four plates, of which the three of the first row rest upon the radials, their sides touching the distichals, the other being much larger and interposed between the radial dome plates. Orals very irregular in their arrangement; the posterior one strictly central, very large and spinous; the others nearly flat, the position of the anterior one strictly interradial, while that of the two antero-lateral ones appears to be almost radial. The covering pieces enter the calyx after the first division of the ambulacra, and the two branches are separated by a rather large plate. The anal opening occupies the upper part of a well defined protuberance, a sort of rounded vertical ridge, which extends from the special anal plate to the posterior oral, and is surrounded by a deep groove.

Horizon and Locality. — Upper part of the St. Louis group, at Tateville, Pulaski Co., Ky., associated with the preceding species.

Types in the collection of Wachsmuth and Springer.

Talarocrinus simplex (SHUM.).

Plate LXXVIII. Figs. 8a, b.

1857. *Dichocrinus simplex* — SHUMARD; Trans. St. Louis Acad. Sci., p. 74, Plate 1, Figs. 2a, b.

1858. *Dichocrinus simplex* — HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 654, Plate 22, Figs. 12a, b.

1882. *Dichocrinus simplex* — W. and SP.; Revision Palæocr., Part II., p. 84.

A small species, the width of the calyx varying from 5 to 9 mm. Dorsal cup generally a little higher than wide, widest at the basi-radial suture or a little above, somewhat cylindrical along the median portions, and gradually contracting toward the arm bases. Plates thick, and without ornamentation or other markings; suture lines distinct, but not grooved.

Basal cup large, semiglobose, extending to fully one half the height of the calyx; the lower end slightly flattened, the central part excavated, forming a narrow circular pit of considerable depth; the salient angles at the upper margin quite obtuse, the re-entering angles toward the anal plate and anterior radial comparatively sharp. Radials slightly differing in form, some being wider than others, but all, as a rule, longer than wide and narrowest at the top. The superior faces of the plates are directed obliquely inward, and the ends are but slightly truncated; they are excavated to one half their width by the facets which contain the costals and distichals. Anal plate generally wider at the bottom than the radials, but narrower at the top.

Costals very minute. Distichals 1×10 in the calyx; of the same proportions as the overlying arm plates. Arms apparently ten, their structure and that of the ventral disk unknown.

Horizon and Locality. — Warsaw limestone. Found at Spergen Hill, Ind., Genevieve Co., Mo., and in many places in Kentucky and Tennessee.

Remarks. — This species has been heretofore referred to *Dichocrinus*, with which, no doubt, it has some affinities; the presence, however, of a single very minute costal, the form and arrangement of the distichals and succeeding brachials, show distinctly its close relations with *Talarocrinus*. The specimens vary considerably in size and somewhat in form; in most of them the sides of the calyx are evenly rounded, while in others they are contracted along the basi-radial suture. Meek and Worthen described a specimen of this kind as a distinct species under the name *D. constrictus*.

PTEROTOCRINUS LYON and CASS.

- 1859. LYON and CASS.; Amer. Journ. Sci., Vol. XXIX., p. 68.
- 1866. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 288.
- 1866. SHUMARD; Trans. St. Louis Acad. Sci., Vol. II., p. 394.
- 1879. WETHERBY; Journ. Cincin. Soc. Nat. Hist., Vol. II. (April number).
- 1879. WETHERBY; *ibid.* (October number).
- 1879. ZITTEL; Handb. der Palæont., Vol. I., p. 365.
- 1881. W. and SP.; Revision Palæocr., Part II., p. 87.
- 1885. W. and SP.; *ibid.*, Part III., p. 120.
- 1889. S. A. MILLER; N. Amer. Geology and Palæont., p. 276.
- Syn. *Asterocrinus* LYON (not Münster 1839); Geol. Rep. Kentucky, Vol. III., p. 472.

Calyx more or less turbinate; the plates heavy and without ornamentation. Dorsal cup saucer-shaped, wider than high; the ventral disk pyramidal, higher than the cup. The disk has five very large conspicuous plates or processes disposed radially, which in the form of wings or horns pass out from between the arms.

Basals two, both pentagonal; the suture passing from the posterior to the anterior side of the calyx. Basal cup shallow, and upon the posterior and anterior sides angularly excavated for the reception of the anal plate and the anterior radial. Radials wider than long, rapidly increasing in width upwards; subquadrangular in outline, except the anterior one, which is angular below, while the others are truncate; the superior faces slightly undulated. Costals but one to the ray, which is often hidden from view, and is always minute and triangular. It supports two distichals, both axillary, which meet over the apex of the costal, their lateral faces resting upon the

radials, their sloping upper faces supporting from 1 to 3×4 fixed palmars, of which the proximal ones touch with their outer faces the radials. There are no interradians nor interaxillaries within the dorsal cup, and, as a rule, there is but one anal plate,* which is elongate-subtriangular, and always considerably smaller than the radials. The plate generally rises to the height of the radials and sometimes beyond them, but occasionally is shorter, and the two posterior radials meet over its apex. Arms twenty, short, biserial, simple, arranged in groups of four, separated by the appendages, so as to divide the arms of the same ray among two compartments. Pinnules short; in close contact. Tegmen highly elevated, pyramidal, pentagonal in outline; the sides of the pyramid interradianally disposed, and longitudinally depressed so as to form niches for the reception of the arms; the angles are excavated or pierced, and support the large radial processes, which do not necessarily pierce the test. Four of the interradian spaces are of similar size, and composed of three to six oblong plates; the posterior one is widest, and its plates are most numerous. The first interambulacral rests upon the sloping outer ends of two adjoining palmars, and between two secondary radial dome plates; it is followed by others, which are distributed around the bases of the wing-like appendages. The anus is almost central, and surrounded by a large number of minute pieces, which form a little cone, or, more frequently, a sort of mammiform protuberance. Orals large, resting directly upon the interambulacra; the posterior one wedged in between the other four.

The wing-like appendages, which probably represent the first radial dome plates, form the most characteristic feature of this genus. Their form is very variable, being in some species spatulate, in others claviform or cuneiform; in some thin and knife-like, in others thick and rounded, while they bifurcate in still others. The plates rise to the full height of the disk, and extend laterally far beyond it and beyond the arms; they generally rest upon the surface of the disk, within pits or grooves formed by the bevelled or inclined lateral edges of the interradian and oral plates. Beneath them there are over each ray two smaller radial dome plates of a second order, which rest against the plates of the dorsal cup, and enclose a large interambulacral plate. The upper edges of the latter plate are excavated, and form the lower ends of the sockets for the appendages. Ambulacra subtegmenal. Column round; axial canal small.

* In one specimen we observed a small triangular piece above the regular anal plate, which we regard as incidental, and not of structural value.

Distribution. — Restricted, so far as known, to the Kaskaskia group of North America. Detached appendages are found in large numbers in certain localities of Alabama, Kentucky, Tennessee, and Illinois, but perfect specimens are extremely rare.

Type of the genus: *Pterotocrinus capitalis* (Lyon).

Remarks. — This genus was originally described by Lyon under *Asterocrinus*, a name preoccupied by Münster. Meek and Worthen, in 1866, in revising the genus, stated that in some species the interradians rest upon the superior lateral faces of the radials, which is the case in the allied *Talarocrinus*, but not in *Pterotocrinus*. Wetherby regarded the small trigonal costals, which Meek and Worthen identified as "second radials," and which Lyon and Casseday had overlooked entirely, as accessory pieces. These plates, although present in every specimen, are in some cases completely covered by the distichals.

Cyathocrinus protuberans Hall very probably belongs to this genus, but as only the basals and portions of radials are known, we are unable to describe it satisfactorily.

It is very interesting that the anus in almost every specimen of this genus is covered with a *Platyceas*, and in every case the anterior margin of the shell is directed to the posterior side of the crinoid, contrary to the cases of *Platycrinus hemisphericus* and *Gilbertocrinus tuberosus*, in which the anterior margin of the shell lies to the anterior side of the crinoid.* That the Gasteropod invariably occupies the same position proves, we think, that its presence there is the result of habit and not of accident. In *Pterotocrinus* it could not have been washed in by the currents of the arms, as suggested by Meek and Worthen in the case of *Platycrinus hemisphericus*, for the arms in some species of *Pterotocrinus* are so short that they do not reach the summit of the calyx.

Pterotocrinus is an aberrant and highly differentiated form. It approaches the typical form of the Camerata in the comparatively large size of the fixed brachials, which to the third order, contrary to what is the case in all typical Hexacrinidæ, constitute a part of the calyx proper. The genus has its closest affinities with *Talarocrinus*, which precedes it in time, and is doubtless its ancestral type. Their structural peculiarities tend in the same direction; but while feebly indicated in the latter form, they attain in *Pterotocrinus* the climax of extravagant development. *Pterotocrinus*, so far as we know, is the

* To this fact Mr. Charles R. Keyes directed attention in his interesting paper, On the Attachment of *Platyceas* to Palæocrinoids (Proceed. Amer. Philos. Soc., Vol. XXV., p. 237).

last surviving genus of the Hexacrinidæ; and it is most interesting to find here again emphasized the truth which Palæontology teaches us by so many examples, that extravagance of form and rank development in any group is the signal for its speedy extinction.

***Pterotocrinus capitalis* (LYON).**

Plate LXXIX. Figs. 6a, b.

1857. *Asterocrinus capitalis* — LYON; Geol. Rep. Kentucky, Vol. III., p. 472, Plate 3, Figs. 1, 1a-b.

1859. *Pterotocrinus capitalis* — LYON and CASSEDAY; Amer. Journ. Sci., Vol. XXIX., p. 68.

1881. *Pterotocrinus capitalis* — W. and SP.; Revision Palæocr., Part II., p. 91.

Crown as viewed from above irregularly star-shaped, in profile resembling the form of a Corinthian capital. Dorsal cup about as wide as high, the plates heavy and without ornamentation.

Basals proportionally larger than in any other known species of the genus, forming a rather deep basin, almost as large as the remaining portions of the dorsal cup together; the sides rounded, contracting at the upper end, and somewhat flattened at the bottom; the median portions slightly concave, with a deep pit in the centre, completely filled by the column. The upper margin of the basal cup is indented for the reception of the radials, and deeply notched for the anal plate. The latter extends to the full height of the radials, but is considerably narrower; it is trapezoidal, the upper angle being acute, the lower one obtuse. Radials very short, their width almost four times their height; the lower face convex, the upper excavated by the radial facets. Costals larger than usual in the genus, wider than long, triangular; the lateral faces a little concave. Distichals twice the size of the costals, wider than long, the upper angles obtuse. Fixed palmars 1×4 , in contact laterally; the two outer ones resting with one of their lower faces upon the radials, with the other against the distichals; the two inner plates of the rays supported exclusively by the distichals; all succeeding brachials free. Arms four to the ray, short, rather strong, tapering to the tips, and incurving. They are biserial from the second plate, and the two series are united by a zigzag suture. Structure of the greater part of the ventral disk not known. The orals, of which portions are exposed, are elongate and almost—some of them completely—separated by the wing-like appendages. The latter, as viewed from the side, are elongate subtrigonal, with rounded outer angles; they are massive, deep, and flattened at the sides, thicker at

the upper end than at the lower, and stouter in the middle than along the margins. The sockets in which they rest have not been observed, but must have been large, and probably extended to near the arm bases. Anus sub-central. Column round and small.

Horizon and Locality. — Kaskaskia group; Crittenden Co., Ky.

Type in the Lyon collection.

Remarks. — Lyon described this species as having but one "primary radial," and two series of "secondary radials," of which the first series is said to consist of two, the other of four plates. He overlooked the small costal, and regarded the two succeeding rows, which are partly distichals and partly palmars, as "secondary radials." He further supposed the wing-like appendages to be composed of three pieces; but the fact is that the suture lines indicated in his Figure 1b on Plate 3 are cracks in the specimen, and that plate evidently does not belong to this species.

***Pterotocrinus coronarius* LYON.**

Plate LXXIX. Figs. 7a, b.

1857. *Asterocrinus* (?) *coronarius* — LYON; Geol. Rep. Kentucky, Vol. III., p. 476, Plate 1, Figs. 1, 1a.
 1859. *Pterotocrinus coronarius* — LYON and CASS., Syn. List Palæoz. Echinod. (Proceed. Amer. Acad. Arts and Sci., Vol. IV., p. 302).
 1881. *Pterotocrinus coronatus* — W. and Sr.; Revision Palæocr., Part II., p. 91 (Proceed. Acad. Nat. Sci. Phila., p. 265).

The structure of the dorsal cup is not known,* but the parts preserved are so characteristic of the genus, and again differ so essentially from the same parts of all other known species, that there can be no doubt that they belong to a distinct species. The tegmen is remarkable for the extravagance of its winged processes, which project out almost horizontally from the calyx, and form with it, as seen from above, a five-rayed petaloid star. The petals, viewed from above, are broad, narrowest at the extremities and slightly bending downward; the margins of the upper face curve upward and form a well defined rim around the median portions. The appendages are massive

* This species was described by Lyon from a single "unique crinoidal fragment," having, as he said, "neither basal, radial, nor arm plates." This is the type specimen which we have figured, and no other is known to have been discovered. Yet it is a singular fact that there is in the Museum of Comparative Zoölogy at Cambridge a lead cast of what seems to have been the same specimen, but having the missing dorsal portion of the calyx intact and showing all the characters of the genus. This cast is supposed to have been given to Professor L. Agassiz about 1850; but whether it was made from a partial restoration of the specimen which afterwards became Lyon's type, or from another almost duplicate specimen, or whether the type was complete as originally found, and the dorsal cup broken off and lost before Lyon's description was made, can only be conjectured.

and form irregular trihedrons with undulating faces and rounded angles, the side by which they are attached to the calyx touching with one end the orals, and with the other the plates of the dorsal cup. The median part of the tegmen (the nucleus of the star) is concave, except its posterior side, which is slightly raised by the anal structures, which occupy fully one third of the central space. Anal opening subcentral; surrounded by numerous small plates, which are enclosed by larger ones of irregular arrangement. The orals vary in size as well as in form; the posterior one, which is wedged in between the others, is pushed over to the anterior side; it is rather small, slightly convex, and subtrigonal in outline, though actually pentagonal; the two anterior orals are larger than the lateral ones. The extreme outer ends of the orals are bent abruptly downward so as to produce, together with the depressed inner ends, sharp edges, which connect with the projecting margins following the appendages, forming with them a well defined rim around the whole upper surface of the calyx. The spaces between the appendages are placed at right angles to the upper face; they are subtriangular in outline, and distinctly grooved for the reception of each separate arm. At the four regular sides there are apparently six interambulacral pieces, and probably eight at the anal side.

Horizon and Locality. — Kaskaskia group; Crittenden Co., Ky.

Type in the Lyon collection, Jeffersonville, Ind.

***Pterotocrinus depressus* LYON and CASS.**

Plate LXXIX. Figs. 2a, b, c, d, e.

1859. LYON and CASSEDAY; Amer. Journ. Sci., Vol. XXIX., p. 68.

1866. SHUMARD; Trans. St. Louis Acad. of Sci., Vol. II., p. 394.

1873. MEEK and WORTHEN; Geol. Rep. Illinois, Vol. V., p. 559, Plate 21, Figs. 13, 13a-c.

1881. W. and SP.; Revision Palæocr. Part II., p. 91.

This species is distinguished from all others by its enormous, flat, knife-like appendages, and by the position of the anus, which occupies the top of a central slender cone. Calyx a little higher than wide; the dorsal cup shorter than the ventral disk, depressed bowl-shaped; the sides straight or slightly convex; the lower portions rounded. Plates smooth and the suture lines rather indistinct.

Basals of moderate size, but very slightly projecting, with a shallow concavity at the bottom, which is completely filled by the column. Radials irregularly pentagonal, the sides rapidly spreading, especially those facing

the anal plate; the upper faces at both ends are slightly excavated for the reception of the two outer palmars of the proximal row, and there are similar excavations at the middle portions for the costals and distichals. The anal plate, which is placed within a notch formed by the basals, is either pentangular or triangular; when pentangular, its lower part rests between the radials, the upper between two of the palmars; when triangular, the two posterior radials meet over its apex. Costals small, trigonal. Distichals as large as the fixed palmars. The latter, of which there are three plates to each series, are wider than high, and quadrangular, except the outer ones of the first row, which are either pentagonal or hexagonal. Arms short, slightly tapering, flattened on the back, and biserial from the fourth or fifth plate. They are composed of very short transverse pieces, which are united laterally by a sharply zigzag suture. Pinnules strong and closely packed. Ventral disk conical, once and a half as high as the dorsal cup; the plates arranged similarly to those of *P. pyramidalis*; but the posterior oral, instead of being central, is pushed completely to the anterior side by the anus. The anal opening is located at the top of a small elongate cone or short tube, which occupies almost the centre of the disk. The interrarial spaces are longitudinally grooved to their full length. Those of the four regular sides are constructed of three good-sized interambulacral pieces, succeeded by the oral plates. The posterior side has 2, 3, and 4 pieces, followed by numerous smaller ones, which support the anal tube. The sockets for the reception of the winged appendages are narrow, the appendages leaf-like, perfectly flat on their lateral faces, and thickest at the place of attachment, whence they thin out gradually into a sharp, knife-like edge. As seen in the specimen, they look like five immense blades, which project out in all directions far beyond the limits of the arms. The interdistichals and secondary radial dome plates are comparatively small, the former less protuberant than in the preceding species.

Horizon and Locality. — Kaskaskia group; Grayson, Edmonson and Pulaski Cos., Ky.

Types in the Lyon collection.

Pterotocrinus pyramidalis LYON and CASS.*Plate LXXIX. Figs. 4a, b.*

1859. LYON and CASSEDAY; Amer. Journ. Sci., Vol. XXIX., p. 69.

1866. SHUMARD; Trans. St. Louis Acad. Sci., Vol. II., p. 394.

1881. W. and SP.; Revision Palæocr., Part II., p. 91.

A little larger than the preceding species. Dorsal cup saucer-shaped, broadly truncate at the lower end; the sides rapidly spreading, especially from the top of the radials upward, bringing the upper portions into a nearly horizontal position. Plates thick and without ornamentation.

Basal cup very short, a little projecting laterally; oblong, the longer diameter transverse to the suture; the upper margin distinctly notched for the reception of the anal plate, and somewhat less toward the anterior radial. Radials subquadrangular, rapidly spreading, fully one third wider at the upper end than at the lower; the median portions of the upper faces slightly excavated for the reception of the distichals and the middle part for the costals. Costals very small, trigonal. Distichals smaller than the palmars. The first and second palmars larger than the third, and forming part of the calyx; the third partly free. The first palmars of the two outer divisions of the ray are pentangular, and rest with their lower faces against the sloping upper faces of the distichals, with one of their lateral faces upon the radials, and the other against the first palmar of the inner division. The second palmars are supported by the first, and rest at one side against the second and third of the two inner divisions, and at the opposite side against the palmars of adjacent rays. The three palmars of the two inner divisions thus meet laterally, and interlock with those of the outer divisions. Arms four to the ray, short, biserial above the third palmar. Anal plate lozenge-shaped, large, its upper end inflected and not seen in a side view. Ventral disk, the appendages removed, pyramidal, the sides flattened or slightly concave, covered with longitudinal grooves for the reception of the arms. The interambulacra at the four regular sides consist of three plates in two rows; they are of about equal size, and all longer than wide; the first, which is flanked by two secondary radial dome plates, is hexagonal, the two succeeding ones pentagonal and in contact laterally with those of adjacent sides. The latter plates, as also the orals, are bevelled off at one side to a third of their width, and the depressions thereby produced form the sockets for the appendages,

which in this species do not penetrate the test, but rest exclusively against the sloping faces of adjoining plates. The anal side has two interambulacral pieces in the first row, and three in the second, which latter are followed by numerous smaller plates. Anal opening subcentral, directed obliquely upwards. The posterior oral occupies a central position, being pushed in between the other four; the latter rest against the interambulacral plates. The form of the appendages is not definitely known, but we judge from the form of the sockets, which are narrow and elongate, and from fragments in contact with the specimen, that they were probably similar in form to those figured by Lyon (Geol. Rep. Kentucky, Vol. III., Plate III., Figs. 1*a*, *b*), which he mistook for the appendages of *P. capitalis*. The interdistichal plates are large, greatly projecting and angular in the lower portions, while they form deep grooves in the upper. Arms unknown. Column round, narrower than the concavity which it occupies.

Horizon and Locality.—Kaskaskia group; Edmonson, Grayson, and Breckenridge Cos., Ky., and Morton Co., Ind.

Type in the Lyon collection.

***Pterotocrinus acutus* WETHERBY.**

Plate LXXIX. Figs. 3a, b, c, d, e, f, g.

1879. WETHERBY; Journ. Cincin. Soc. Nat. Hist., Vol. II. (October No.), Plate 11, Figs. 2*a-c*.

1881. W. and SE.; Revision Palæocr., Part II., p. 91.

Syn. *Pterotocrinus spatulatus*—WETHERBY; Journ. Cincin. Soc. Nat. Hist., Vol. II. (October No.), Plate 11, Figs. 3*a-c*.

Syn. (?) *Pterotocrinus rugosus*—LYON and CASS., 1859; Amer. Journ. Sci., Vol. XXIX., p. 71.

Of the type of *P. pyramidalis* Lyon and Cass.; but the basal cup much smaller and the bottom less deeply excavated than in that species, the radials proportionally longer, the anal plate smaller, and the sockets for the reception of the radial appendages wider. The appendages have the shape of a horn terminating in a point instead of an edge. Dorsal cup low basin-shaped, the upper portions flanging outward; pentangular across the arm bases.

Basal disk very shallow, rounded at the outer face, not truncate at the bottom, and but slightly excavated. Neither the interbasal nor basi-radial sutures are grooved. Radials short, somewhat irregular in form; their upper faces moderately concave; once and a half as wide at the top as at the bottom, and twice as wide as long. Anal plate lozenge-shaped, the acute upper angle wedged in between the radials, the obtuse lower angle resting upon the

basals. The costals very minute, sometimes completely covered by the distichals, which are a little larger than the palmars. The latter, to the height of the third plate, consist of short, transverse, single pieces, the plates of the two lower rows being included in the calyx; while those of the third row, which are surmounted on the back by a small spine or elongate node, are free. Arms biserial from the fourth plate, and composed of two rows of very short pieces, which are united laterally by a zigzag suture. The arms are flat, tapering, and so short that their ends do not meet upon the summit. Ventral disk pyramidal, a little shorter than wide. Interambulacral spaces triangular, and to their full height covered with small longitudinal grooves in which the arms rest. At the four regular sides there are four plates, three of them interambulacral, arranged: 1 and 2, followed by an oral plate. The two upper interambulacral pieces and the orals are strongly bevelled at one side to form the sockets for the appendages. The upper parts of the four smaller orals bend abruptly inward, and form a sort of platform, which is almost invariably occupied by a specimen of *Platyceras chesterense*, so as to cover the anal opening and the posterior oral. Anal interradius a little the widest, and composed of a much larger number of plates. It has also only one plate between the arm bases, but this is followed by three or four pieces, and numerous others which gradually decrease in size upwards. The posterior oral is convex and semilunate, one of its sides being excavated by the anal opening, which is almost central. The sockets for the appendages are widest at the top, whence they taper gradually downward, and form a sharp angle which enters the upper end of the interdistichal below. The appendages are long and somewhat variable in form; as a rule, they are wider on top than at the bottom, a little deeper than wide, deepest at the proximal ends, and they terminate either in a sharp point or a transverse edge. Column small and round.

Horizon and Locality.—Kaskaskia group; Sloans Valley, Pulaski Co., Ky.

Types in the collection of Professor Wetherby.

Remarks.—We regard *Pterotocrinus spatulatus* Wetherby as identical with the above species. The two were said to differ in the form of their appendages, the one being awl-shaped at the distal end, the other more spatulate. Comparing the figures of the type specimens, the difference is very slight, and a comparison of a large number of spines collected from the dumps of the Sloans Valley tunnel shows conclusively that there are within the limits of this species even greater variations than those referred to.

Lyon's *Pterotocrinus rugosus* is probably also identical with this species, but as the type specimen is fragmentary and badly crushed, no critical comparison is possible, and we think it advisable to accept Wetherby's name.

***Pterotocrinus acutus*, var. *bifurcatus* (WETHERBY).**

Plate LXXIX. Figs. 9a, b.

1879. WETHERBY; Journ. Cincin. Soc. Nat. Hist. (October No.), Plate 11, Figs. 1a, b, c.

1881. W. and Sp.; Revision Palæocr., Part II., p. 91 (Proceed. Acad. Nat. Sci. Phila., p. 265).

This variety agrees in the general arrangement of its plates with *P. acutus*, but differs from it in the form of the dorsal cup and the form of the appendages. The cup is higher and more conical; the basals proportionally deeper, their lower faces distinctly excavated, and sharply edged around the margin. The appendages are long and extremely heavy throughout; they bifurcate widely, in such a way that the divisions from adjoining rays meet at their ends and sometimes overlap each other. Column small, filling scarcely one half of the basal cavity.

Horizon and Locality.—Kaskaskia group; Sloans Valley, Pulaski Co., Ky.

Type in the collection of Prof. A. G. Wetherby.

***Pterotocrinus crassus* MEEK and WORTHEN.**

Plate LXXIX. Fig. 8.

1860. *Dichocrinus (Pterotocrinus) crassus* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila., p. 382.

1860. *Pterotocrinus crassus* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 290, Plate 23, Figs. 2a, b.

1881. *Pterotocrinus crassus* — W. and Sp.; Revision Palæocr., Part II., p. 91.

This species has its closest affinities with *P. pyramidalis* Lyon and Cass., but is somewhat larger, the basal cup deeper, the arms longer and heavier. Dorsal cup basin-shaped, more than twice as wide as high, very broad at the base, the sides less spreading than in any of the preceding species, and somewhat constricted at the basi-radial suture.

Basals very large, forming a rounded shallow cup, distinctly concave below, and widening gradually from the rounded lower margin to the constricted upper face. Radials a little convex, broader than long, considerably wider above than below; their upper faces slightly concave, supporting the costals, distichals, and the outer palmars of the first row. Anal plate sub-quadrangular, contracted above, the upper end inflected. Costals very small,

often altogether hidden from view. Distichals and lower arm plates nearly of equal size. The arms free from the second plate, and biserial from the fourth; they are unusually strong, rounded at the back, and composed of two rows of short, transverse pieces. Pinnules slender and closely arranged. The appendages are thin and knife-like at their upper edges, much thicker below (Meek and Worthen) than above. Construction of the ventral disk unknown. Column round, occupying about one fourth of the basal concavity.

Horizon and Locality. — Kaskaskia group; Hardin Co., Ills.

Type in the Illinois State collection, Springfield.

***Pterotocrinus chesterensis* MEEK and WORTHEN.**

Plate LXXIX. Figs. 5a, b.

1860. *Dichocrinus (Pterotocrinus) chesterensis* — MEEK and WORTHEN; Proceed. Acad. Nat. Sci. Phila. p. 383.
 1866. *Pterotocrinus chesterensis* — MEEK and WORTHEN; Geol. Rep. Illinois, Vol. II., p. 292, Plate 23, Figs. 1a, b, c.
 1881. *Pterotocrinus chesterensis* — W. and SP.; Revision Palæocr., Part II., p. 91.

The smallest known species of the genus. Sides of the dorsal cup distinctly concave, rapidly spreading upwards; the base truncated, and its lower margin projecting; the plates without ornamentation, and the suture lines not grooved.

Basal cup about one third the width of the calyx at the arm bases, and about three times as wide as high, truncated and concave below, the concavity surrounded by an angular rim. Radials not quite twice as wide as long, widening rather rapidly from below, the superior faces a little excavated except the outer ends, which are slightly truncated. Costals small, triangular. Distichals irregularly pentagonal. Fixed palmars four; the two outer ones in the same line with the distichals, and like them reposing upon the radials. Anal piece subovoid, its broadest end about as wide as the radials at their lower faces, the upper end angular. Arms biserial from the third plate up, small, and rounded on the back. Structure of ventral disk and form of the appendages unknown.

Horizon and Locality. — Kaskaskia group; Hardin Co., Ills.

Type in the (Worthen) Illinois State collection, Springfield.

ACROCRINIDÆ W. and SP. (1885).

MONOCYCLIC. BASALS SEPARATED FROM THE RADIALS BY A LARGE BELT OF ACCESSORY PIECES. RADIALS IN CONTACT EXCEPT AT THE POSTERIOR SIDE, WHERE THEY ARE SEPARATED BY AN ANAL PLATE. STRUCTURE OTHERWISE AS IN THE HEXACRINIDÆ.

Geological and Geographical Distribution.

Number of known species.

FORMATION.		ACROCRINUS.
Carboniferous.	Coal Measures.	1
Subcarboniferous.	Kaskaskia group.	1
	St. Louis group.	1
Total species		3

Remarks. — This family consists of the single genus *Acrocrinus*, which is only known from America, where three species have been found: one in each of the upper members of the Subcarboniferous, and one in the Coal Measures. It represents, therefore, the end of the Camerata, so far as our present knowledge goes. It appeared after all the other families were extinct, except a small remnant of the Platycrinidæ represented by a small but very prevalent species, and the Hexacrinidæ, from which its derivation is very apparent. It survived in the Carboniferous, from which a single very small specimen is known.

In the interposition of accessory pieces between the primary plates of the calyx, the Acrocrinidæ approach the Reteocrinidæ; but the two families

differ essentially in other respects. In the Reteocrinidæ these pieces are introduced along the sides of the radials and the lower brachials, and between the primary interbrachials, but in the Acrocrinidæ below the radials and between them and the basals. In the one group the basals are in contact with the radials, and the radials are separated all around, while in the other the radials are in contact except at the anal side, but are widely separated from the basals by a new set of plates, for which the term "subradials," if it had not been otherwise used, would be appropriate.

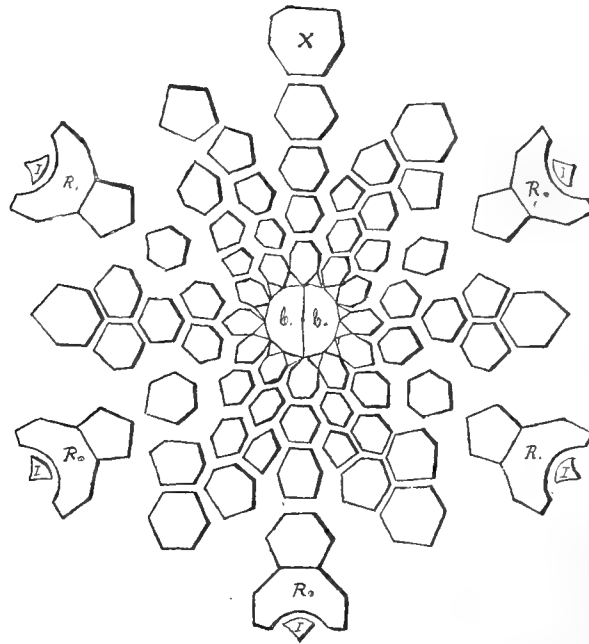


Fig. 21. *Acrocrinus*.

b. = basals; *R.* = radials; *I.* = costals; *x.* = special anal plate. All the other plates are supplementary pieces.

The Acrocrinidæ are undoubtedly closely related to the Hexacrinidæ; in fact the introduction of a narrow belt of supplementary pieces between the basals and radials would be sufficient to transform any *Dichocrinus* into an *Acrocrinus*. In both genera there are two equal basals, the radials of both enclose an anal plate, in both of them the arms are sometimes pendent, and neither one has interbrachials entirely within the dorsal cup. Considering that the number of these supplementary pieces increases with the growth of the crinoid, as is shown conclusively from the specimens, it seems to us more

than probable that *Acrocrinus* represents phylogenetically a highly differentiated form of *Dichocrinus*. This is further confirmed by the fact that *Acrocrinus*, while in part contemporaneous with *Dichocrinus*, is, so far as known, the last surviving genus of the Camerata.

ACROCRINUS YANDELL.

1855. YANDELL; Amer. Journ. Sci. and Arts, Vol. XX. (new ser.), p. 135.
 1858. HALL; Geol. Rep. Iowa, Vol. I., Part II., p. 689.
 1882. WACHSMUTH; Bull. I. Illinois State Museum, p. 41; and Geol. Rep. Illinois, Vol. VII., p. 343, Plate 30, Fig. 13.
 1885. W. and SP.; Revision Palæocr., Part III., p. 124 (Proceed. Acad. Nat. Sci. Phila., p. 346).

Calyx amphora- or urn-shaped, longer than wide. Basals two, equal, forming a low basin or flat disk; the suture line passing from the anterior to the posterior side; the upper face straight. Radials separated from the basals by an indefinite number of supplementary pieces placed in rows, alternately arranged, except those supporting the anal plate and anterior radial; those of every succeeding row are somewhat larger. The plates are in part radial and in part interradial, the latter considerably the most numerous at the posterior side; the uppermost row supports the radials, which are moderately large and enclose an anal plate. Radials at their upper faces broadly and deeply excavated for the reception of the costals and distichals. Costals very small, subtrigonal. Distichals two, the lower one placed against the sloping faces of the costals and upon the radials. Palmars two if there is another bifurcation. Arms biserial, either erect or pendent; in the latter case the ambulacra exposed. Pinnules long and closely packed. Ventral disk flat, composed of small plates. Anal opening eccentric, near the margin of the disk.

Distribution. — *Acrocrinus*, the only genus of the Acrocrinidæ, is represented, so far as known, only in America, and there only by three species, which range from the St. Louis group to the Coal Measures.

Type of the genus: *Acrocrinus Shumardi*.

Remarks. — In the Revision, Part III., we described this genus as having "three radials," or, as we would say now, a radial and two costals. Since then we have obtained very much better specimens than were ever known before, and these prove conclusively that the so-called first radial is merely an accessory piece, and that the plate above it is the true radial. Our interpretation seemed to be quite reasonable in the case of *A. Wortheni*, in which the lower face of the radials rests upon a single plate, which natu-

rally occupies a radial position; but it does not agree with *A. Shumardi*. In this species there are only two plates in radial succession; the plate which we described as the "second" radial rests upon two contiguous plates, which are both interradsial.

The accessory pieces were multiplied by the addition of new rings above the basals. This is well shown by the small specimen of *A. Wortheni*, and by some of the smaller specimens of *A. amphora*, in which the plates of the last ring are yet trigonal, while in the larger specimens, with additional rings, they are heptagonal.

***Acrocrinus Shumardi* YANDELL.**

Plate LXXX. Figs. 1, 2, 3.

1847. YANDELL and SHUMARD; Contributions Geology Kentucky, Plate 1, Fig. 3 (figured without description or name).
 1855. YANDELL; Amer. Journ. Sci. and Arts, Vol. XX. (new ser.), p. 135 (with figure).
 1885. W. and SP.; Revision Palaeocr., Part III., p. 122.
 Syn. *Acrocrinus urnaformis* — HALL; 1858, Geol. Rep. Iowa, Vol. I., Part II., p. 690, Plate 25, Figs. 9a, b.

A large species. Calyx urn-shaped, apparently more than twice as long as wide; the plates thin, almost flat, and without ornamentation.

Basals forming a large basin; the lower face rather broadly truncated, and extended outward into a small rim; the interbasal suture slightly grooved. The plates separating the basals from the radials arranged in fourteen to twenty rings, more or less, each ring containing from twenty-five to thirty plates, except the upper one which has but eighteen. They are arranged in a similar manner as in *A. Wortheni*, gradually increasing in size upward, and the lower ones longer than wide, the upper as wide as long. Radials irregularly heptagonal, larger than any of the preceding plates, short but extremely wide, their width being three to four times their height; the upper face of the radials is excavated to fully three fourths its width, forming a deep, rounded facet, which encloses the costals and both distichals. Anal plate a little longer than the radials, and like these supported by four plates. Costals one, minute, trigonal, occupying about one tenth the width of the facet. Distichals and palmars two, transversely linear; the latter but half the width of the distichals. Arms apparently eight to the ray, erect and biserial. The structure of the disk has not been observed, but it was doubtless flat, and the anal opening, as shown by the specimens, frequently was covered by a Gasteropod. Column of moderate size, composed of rather

short joints, which near the calyx, at intervals of five to six, are interrupted by longer and somewhat wider plates.

Horizon and Locality.—Kaskaskia group; Grayson and Pulaski Cos., Ky.

Type in the Yandell collection at Louisville.

Remarks.—The fragmentary specimen from the same horizon of Pope Co., Ills., for which Hall proposed the name *Acrocrinus urnæformis*, is in all probability identical with this species. It has preserved only the basals and a few rings of the intercalated plates, which are not sufficient for accurate comparison.

***Acrocrinus Wortheni* WACHSMUTH.**

Plate LXXX. Figs. 10a, b.

1882. WACHSMUTH; Bull. I. Illinois State Museum Nat. Hist., p. 41; and Geol. Rep. Illinois, Vol. VII., p. 343 (with diagram).

1885. W. and SP.; Revision Palæocr., Part III., p. 124.

This species was described from a single specimen, of which only the dorsal cup is preserved. This, however, is in excellent preservation, and, notwithstanding its small size, every plate can be readily traced. The cup is calyculate, broadly truncate at the bottom, whence it curves rather abruptly upward, its width slightly decreasing to the upper end. The entire length of the specimen is but 5 mm. by $4\frac{1}{2}$ mm., its greatest width, and 4 mm. across the top of the radials. The surface of the plates is without ornamentation, but sufficiently convex to bring out the suture lines.

Basals comparatively large, restricted to the truncated lower face of the calyx, and not visible from a side view; they are separated from the radials by six rings of plates, which increase in size upward. There are twelve plates in the first ring, triangular in outline, which are so minute that it requires a good magnifier to discover them. Another row of twelve somewhat larger plates constitutes the second ring. The latter are joined by their lateral faces, the lower angles resting between the sides of the preceding plates. Five of them are placed radially, seven interr radially, one at each regular interr adial side, and three at the anal side. Ten of the plates are hexagonal, the middle one of the anal side and the anterior radial one heptagonal and truncated above. The third ring consists of fourteen pieces, larger than the preceding ones, but less regular in their arrangement; twelve of them alternate with the plates of the second ring, and the two others rest upon the truncated upper faces of the two larger heptagonal

pieces of the anterior and posterior sides; by this arrangement the piece directed anteriorly is the only radial plate of this ring; five plates occupy the anal interradius, and the four other sides each have two. The fourth ring has sixteen plates; some hexangular, others pentangular, five of them radial, the others interrarial; of the latter, five occupy the posterior side, one the postero-lateral sides, and two the antero-lateral ones. The fifth ring contains twelve plates, all of which are interrarial and arranged in groups of 4, 2, 2, 2, 2. At four sides, the two adjoining plates of different interrarii meet radially by their lateral angles; but at the posterior side, which has four plates, the two middle ones are separated by plates from the fourth and sixth rings, which meet between them. Of the sixth ring, which is followed by the radials, five of the plates are radial, seven interrarial; three of the latter occupy the anal side, two the regular sides. There are in all seventy-eight accessory pieces, of which sixteen are radially disposed, the others interrarially. The radial plates of the anterior side, and the plates of adjoining interrarii together, are arranged exactly like the plates of the posterior side, there being in either case an uninterrupted series of four plates arranged longitudinally, and ten plates to each side; but, while the one row supports a radial, the other bears an anal plate. The true radials of the species are larger than the plates which support them, wider than high, and hexangular; their truncated lower faces rest upon the radial plates of the preceding ring, the lower sloping faces upon the adjoining interrarial pieces. The upper faces of the radials are excavated to three fourths their width into a rounded facet similar to that of *Platycrinus*. The anal plate is somewhat longer than the radials, but narrower.

Horizon and Locality. — Coal Measures; Peoria Co., Ills.

Type in the Illinois State collection at Springfield.

Acrocrinus amphora W. and Sr. (nov. spec.).

Plate LXXX. Figs. 4 to 9.

Smaller than *A. Schumardi*. Calyx urn-shaped, more than twice as high as wide, gradually widening from the lower end to the middle, then contracting a little to the top of the radials. The plates thin, very slightly convex, and without ornamentation.

Basals small for the genus, forming a rapidly spreading basin with a slight truncation at the lower end, corresponding to the width of the column.

The basals are followed by from fifteen to twenty rings of accessory pieces — the number varying among the specimens — and each ring consists of twenty to twenty-four plates, except the two upper rings, which contain but twelve. Of the upper ring, seven plates are arranged interradially — three occupy the anal side and one the regular sides — which alternate with the radial pieces. Most of the accessory pieces are hexagonal, and angular at top and bottom; but at the anterior and posterior sides those constituting the middle series are truncated at both ends. Radials large, one third wider than long, deeply excavated at the upper face into a facet which contains the costal and both distichals. Anal plate of the same width as the radials but considerably longer. It supports several small plates, which project outward, and may be readily taken for the base of an arm. Costals wider than in the two preceding species, but equally short; the distichals proportionally longer and narrower, rounded on the back, and distinctly curving outward. Palmars free from the second or third plate, curving outward and downward, bringing the arms into a pendent position, their backs next to the calyx, and the ambulacra and pinnules on the outside. Arms twenty, moderately long, descending far beyond the basals; they are composed from the fourth or fifth plate of two series of rather short joints, and rest, apparently immovably, with their backs within deep longitudinal grooves or impressions on the surface of the dorsal cup. Pinnules long, closely packed; composed of long joints three times as long as wide, their ventral furrows, like those of the arms, lined by two rows of covering pieces. Ventral disk flat, the middle portions composed of numerous small perisomic plates, from which well defined ambulacral pieces, alternately arranged and suturally united, curve downward, and pass out into the arms. Anus eccentric, on a level with the upper surface, placed about half way between the centre of the disk and its outer margin. Column round, the joints nearly of equal size.

Horizon and Locality. — St. Louis group; near Huntsville, Ala., where we obtained a considerable number of specimens.

Types in the collection of Wachsmuth and Springer.

Remarks. — This species is readily distinguished from *A. Shumardi* by its smaller size and recumbent arms, and from *A. Wortheni* by the different form of the calyx and the much smaller number of accessory pieces of that species.

The arms of this species were apparently immovable, as is indicated by

the structure of the ventral disk, in which the covering plates of the different arms for quite a distance are suturally connected, so as to prevent motion. It is further shown by the deep impressions upon the surface of the dorsal cup, which evidently originated from constant pressure of the arms upon the plates in the growing crinoid.

INDEX.

INDEX TO AUTHORS CITED.

- | | |
|---|---|
| Agassiz, Alexander, 28, 42, 47, 51, 144. | Fraipont, J., 23. |
| Agassiz, Louis, 14, 647. | Geinitz, H. B., 216. |
| Agricola, 11. | Goette, A., 28, 64, 92. |
| Allman, G. J., 28, 89. | Goldfuss, G. A., 13, 23, 335, 647. |
| Angelin, N. P., 30, 58, 267, 280, 330, 335. | Greeff, R., 28. |
| Austin, Thomas, and Thomas, Jr., 15, 22, 309, 649. | Grenfell, J. G., 22, 237. |
| Barris, Wm. H., 21, 324, 325. | Grewingk, C., 23. |
| Barrois, C., 28. | Guettard, J. E., 11. |
| Bather, F. A., 22, 31, 32, 37, 59, 67, 76, 114, 115, 126, 127, 129, 132, 136, 138, 153, 157-161. | Hall, James, 18, 20, 50, 66, 142, 191, 193, 237, 262, 282, 285, 289, 290, 294, 311, 320, 335, 340, 367, 389, 397, 413, 428, 450, 470, 509, 526, 575, 587, 602, 613, 616, 655, 669, 735. |
| Bell, F. J., 28. | Hall and Whitfield, 666. |
| Beyrich, E., 23. | Hinde, G. J., 748, 751. |
| Billings, E., 21, 146, 177, 279. | Heisinger, W., 14. |
| Billings, Walter R., 21, 137, 198. | Heusinger, C. F., 14. |
| Blumenbach, J. F., 12. | Jaekel, Otto, 23, 54. |
| Bronn, H. G., 294. | Jeffreys, J. G., 28. |
| Buch, Leop. von, 17. | Keyes, Chas. R., 793. |
| Bury, H., 28, 53, 65, 153. | Koninck, de, and Le Hon, 11, 17, 21, 23, 68, 77, 80, 216, 236, 294, 335, 649, 757. |
| Carpenter, P. Herbert, 22, 27, 28, 32, 45, 47, 49, 50, 51, 52, 53, 54, 62, 69, 70, 80, 85, 89, 90, 91, 92, 94, 103, 104, 105, 108, 111, 112, 114, 115, 117, 126, 141, 144, 146, 148, 236. | Kunisch, H., 23. |
| Carpenter, Wm. B., 22, 28, 140. | Lamarek, J. B. de, 12. |
| Casseday, S. A., 18, 366, 367. | Leuckart, F. S., 27, 144. |
| Chapman, E. J., 21, 30. | Linné, C., 12. |
| Clarke, J. M., 298, 752. | Loriol, P. de, 22, 53, 61, 69, 117. |
| Conrad, 18. | Lovén, S., 22. |
| Cumberland, G., 13, 22, 236. | Ludwig, H., 28. |
| Cuvier, G., 12. | Lütken, C. F., 22. |
| Delle Chiaje, 14. | Lyon and Casseday, 21, 236, 775, 782, 793. |
| Dujardin and Hupé, 18, 189, 191, 216, 236, 646. | Lyon, S. S., 21, 53, 311, 313, 327, 329, 795. |
| Eichwald, E., 23. | Lyon, Victor W., 311. |
| Etheridge and Carpenter, 91, 146. | Mantell, G., 14, 22. |
| Etheridge, Jr., R., 23. | McCoy, F., 22, 23, 647. |
| Follman, Otto, 23, 294. | McChesney, J. H., 367, 434. |
| | Meek, F. B., 22, 66, 272, 671. |
| | Meek and Worthen, 21, 237, 238, 386, 413, 431, 434, 483, 486, 554, 610, 611, 635, 679, 699, 793. |

- Meyer, H. von, 23.
 Miller, J. S., 12, 520, 555, 647.
 Miller, S. A., 21, 30, 49, 52, 66, 69, 174, 175, 189, 197, 204, 205, 211, 217, 252, 267, 273, 282, 426, 485, 486, 504, 517, 526, 549, 578, 597, 646, 650, 655, 663, 664, 748, 751, 777.
 Miller, S. A., and Dyer, 338.
 Miller, S. A., and Gurley, 384, 409.
 Müller, Joh., 14, 23, 68, 81, 117, 140, 152, 191, 294, 486, 515, 646, 647.
 Münster, Graf von, 14, 23, 793.
 Murchison, R. L., 14.
 Neumayr, M., 23, 29, 47, 91, 95, 98, 102, 115, 148.
 Oehlert, D., 22.
 Orbigny, A. d', 14, 16, 191, 216, 647.
 Owen and Shumard, 18, 671.
 Pander, C. H., 14.
 Parkinson, J., 22.
 Perrier, E., 28.
 Phillips, J., 14, 22, 236, 335, 647.
 Pictet, F. J., 17, 191, 216, 236, 646.
 Pourtales, L. F. de, 28, 58.
 Quenstedt, F. A., 23, 38.
 Ringueberg, E. N. S., 21, 346.
 Roemer, Ferd., 15, 16, 18, 23, 68, 146, 189, 219, 236, 267, 294, 302, 330, 335, 483, 587, 646, 740.
 Rofe, 22, 237.
 Rosinus, 11.
 Rowley and Hare, 21.
 Sandberger, G., 23.
 Sars, M., 28.
 Savigny, J. C., 14.
 Say, T., 14.
 Schlotheim, E. F., 13.
 Schultze, L., 22, 23, 69, 294.
 Schweigger, A. F., 12.
 Sedgwick and Murchison, 14.
 Shumard, B. F., 18, 286, 782.
 Sowerby, G. B., 14.
 Steininger, A. F., 14, 23.
 Steinmann, G., 23, 30.
 Thompson, J. V., 14.
 Thomson, Sir Wyville, 22, 49, 144.
 Trautschold, H., 23, 80.
 Troost, G., 19, 679.
 Ulrich, E. O., 21.
 Vogt and Yung, 28.
 Volborth, A. von, 23.
 Waagen, W., 23.
 Wachsmuth, C., 22, 25, 90, 114.
 Wachsmuth and Springer, 25, 26, 28, 29, 59, 63, 70, 90, 91, 92, 93, 108, 149, 157, 174.
 Wagner, R., 23, 117.
 Walther, J., 23, 53, 68.
 Wetherby, A. G., 21, 146, 793.
 Wirtgen and Zeiler, 219.
 Whiteaves, J. F., 21, 748, 751.
 White, C. A., 21, 252, 367, 436.
 Whitfield, R. P., 21, 192, 358, 398.
 Williams, S. H., 21, 69, 748, 751.
 Worthen, A. H., 21, 69, 207, 773, 775, 788.
 Yandell and Shumard, 18.
 Zenker, J. C., 14.
 Zittel, Carl von, 15, 23, 53, 54, 69, 91, 115, 117, 145, 189, 191, 216, 267, 282, 330, 335, 646.

GENERAL INDEX.

The names of Genera and Species considered to be valid are printed in boldfaced type; those in Italics are regarded as Synonyms. Terms not used by us are also in Italics. The bolder faced figures indicate the page at which the genus, species, or term is defined.

- Abacocrinus**, 363.
 Abactinal System, plates of, **38**.
 Abnormal growths, 135, 547. (Pl. IV, figs. 9-17.)
Acacocrinus, 362, **515**.
 — **americanus**, **516**.
 — **Elrodi**, **515**.
Acanthocrinus, 216, 218.
 — *longispinus*, 219.
Acrocrinidæ, 52, 83, 105, 163, 170, **803**.
Acrocrinus, 86, 485, 804, **805**.
 — **amphora**, 806, **808**. (Pl. LXXX, figs. 4-9.)
 — **Shumardi**, 805, **806**, 809. (Pl. LXXX, figs. 1-3.)
 — *urnæformis*, 806.
 — **Wortheni**, 165, 806, **807**, 809. (Pl. LXXX, figs. 10a, b.)
 Actinal System, plates of, 38, **88**.
Actinoecrinidæ, 79, 86, 165, 170, **550**.
Actinoecrinites, 409, 431, 519.
Actinoecrinus, 13, 69, 83, 85, 120, 121, 129, 308, 365, 409, 413, 486, 519, 547, 550, **552**, 554, 578, 586, 601, 626, 720.
 — *abnormis*, 546.
 — *ægilops*, 628.
 — *æqualis*, 371.
 — *æquibrachiatus*, 440.
 — — var. *alatus*, 441.
 — *althæa*, 632.
 — *amphora*, 587.
 — *amplus*, 520, 530.
 — *andrewsianus*, 433.
 — *araneolus*, 581.
 — *Arnoldi*, 624.
 — **arrosus**, **577**. (Pl. LV, figs. 7-8c.)
Actinoecrinus asperrimus, **575**. (Pl. LX, figs. 5, 6.)
 — *asterias*, 558.
 — *asteriscus*, 441.
 — *biturbinatus*, 427.
 — *Blairi*, 625.
 — *brevicornis*, 533, 535.
 — *brevis*, 511.
 — *Brittsi*, 597.
 — *brontes*, 562.
 — *calyculoides*, 395.
 — *calypso*, 483.
 — *carica*, 448.
 — *Caroli*, 424.
 — *Cassedayi*, 483.
 — *cauliculus*, 483.
 — *chloris*, 571.
 — **chouteauensis**, **570**. (Pl. XLVI, figs. 11a-b.)
 — *Christyi Shum.* 409.
 — *Christyi Hall*, 409.
 — *clarus*, 612.
 — *clio*, 393.
 — *clivosus*, 630.
 — *cloelia*, 398.
 — *clypeatus*, 380.
 — *cœlatus*, 618.
 — *concavus*, 482.
 — *concinus*, 582.
 — *Copei*, 598.
 — *corbulis*, 399.
 — *corniculus*, 511.
 — *cornigerus Hall*, 458.
 — *cornigerus Lyon*, 548.
 — *coronatus*, 403.
 — *Coreyi*, 510.

- Actinoecrinus dalyanus*, 601.
 — *daphne*, 574. (Pl. LVI, fig. 1.)
 — *decornis*, 458.
 — *delicatus*, 628.
 — *desideratus*, 463.
 — *discoideus*, 369.
 — *divaricatus*, 458.
 — *divergens*, 588.
 — *dodecadactylus*, 432.
 — *doris*, 371.
 — *ectypus*, 611.
 — *erodus*, 630.
 — *eryx*, 625.
 — *eucharis*, 549.
 — *euconus*, 430.
 — *excerptus*, 601.
 — *fuscillus*, 512.
 — *formosus*, 369.
 — *fossatus*, 620.
 — *Fosteri*, 601.
 — *gemmiformis*, 449.
 — *glans*, 625.
 — *globosus*, 532.
 — *glyptus*, 640.
 — *Gouldi*, 456.
 — *gracilis*, 572. (Pl. LVI, fig. 11.)
 — *grandis*, 381, 564, 567.
 — *Griffithi*, 568. (Pl. LII, fig. 7.)
 — *Hageri*, 445.
 — *helice*, 481.
 — — var. *eris*, 481.
 — *Humboldti*, 555.
 — *hurdianus*, 601.
 — *icosidactylus*, 368.
 — *indianensis*, 415.
 — *inflatus*, 591.
 — *infrequens*, 604.
 — *inornatus*, 380.
 — *insculptus*, 630.
 — *jugosus*, 563. (Pl. LIV, fig. 1.)
 — *kentuckiensis*, 548.
 — *Konincki*, 447.
 — *lagena*, 601.
 — *lagunculus*, 453.
 — *laura*, 384.
 — *lepidus*, 372.
 — *leucosia*, 401.
 — *limabrachiatus*, 608.
 — *livatus*, 633.
 — *lobatus* (Hall), 557. (Pl. LII, figs. 1a, b; LIV, fig. 3; LV, figs. 1a, b.)
 — *Actinoecrinus lobatus* (Worthen), 567.
 — *locellus*, 605.
 — *longirostris*, 442.
 — *longus*, 609.
 — **Lowei**, 562. (Pl. LIV, fig. 2.)
 — *lucina*, 603.
 — **magnificus**, 558, 567. (Pl. LIII, fig. 2.)
 — *matuta*, 396.
 — — var. *attenuata*, 397.
 — *Meeki*, 290.
 — *minor*, 533, 535.
 — *mississippiensis*, var. *spiniger*, 455.
 — *missouriensis*, 463.
 — *moniliformis*, 520.
 — *multibrachiatus*, 617.
 — — var. *echinatus*, 617.
 — *multicornus*, 309.
 — **multiradiatus**, 109, 555. (Pl. LII, figs. 3-6.)
 — **multiramosus**, 564. (Pl. LIII, fig. 1; LV, fig. 3.)
 — — Parasites of, 566.
 — *mundulus*, 382.
 — *Nashvillae*, 435.
 — — var. *subtractus*, 436.
 — *nodobrachiatus*, 622.
 — *nodosus*, 604.
 — *nyssa*, 548.
 — *oblatus*, 431.
 — *opusculus*, 607.
 — *ornatissimus*, 621.
 — *ornatus*, 597.
 — *ovatus*, 606.
 — *papillatus*, 380.
 — *parvus*, 455, 477.
 — *pendens*, 468, 470.
 — *penicillus*, 635.
 — *pentagonus*, 579.
 — *pentaspinus*, 309.
 — **pernodosus**, 561. (Pl. LV, figs. 2a, b.)
 — *perumbrosus*, 638.
 — *pistilliformis*, 437.
 — *pistillus*, 378.
 — *planobasilis*, 588, 590.
 — *planodiscus*, 411.
 — *plumosus* (detached arms).
 — *pocillum*, 484.
 — *polydactylus* (Bonny), 296.
 — *polydactylus* (Miller), 296.
 — *præcursor*, 484.
 — *proboscidalis*, 601.

- Actinocrinus prumiensis**, 470.
 — *puleatus*, 603.
 — *pyramidatus*, 512.
 — *pyriformis*, 437.
 — — *var. rudis*, 437.
 — *quadrispinus*, 588, 590.
 — *quaternarius*, 601.
 — — *var. spiniferus*, 601.
 — *quinguangularis*, 118, 120.
 — *quinqulobus*, 460.
 — *ramulosus*, 387.
 — *regalis*, 638.
 — *remibrachiatus*, 388.
 — *reticulatus*, 605.
 — *rotundus*, 431.
 — *rudis*, 630.
 — *rusticus*, 559.
 — **scitulus**, 559. (Pl. LV, figs. 5-6b.)
 — *sculptus* (Hall), 583.
 — *sculptus* (Miller), (detached columns).
 — *securus*, 614.
 — *sedaliensis*, 555.
 — *semiradiatus*, 289.
 — *senarius*, 597.
 — *sexarmatus*, 615.
 — *Sillimani*, 559.
 — *similis*, 382.
 — *sinuosus*, 385.
 — *speciosus*, 638.
 — *spinobrachiatus*, 591.
 — *spinosulus*, 478.
 — *spinotentaculus*, 619.
 — *stellaris*, 109.
 — *subaculeatus*, 476.
 — *subæqualis*, 369.
 — *subturbatus*, 466.
 — *subumbrosus*, 633.
 — *subventricosus*, 593.
 — *superlatus*, 533, 535.
 — *symmetricus*, 477.
 — *tenuidiscus*, 520, 531.
 — *tenuiradiatus* (Hall, 1861, not 1847), 634.
 — **tenuisculptus**, 555, 571, 574, 609, 622. (Pl. LV, figs. 4a, b.)
 — *thalia*, 604.
 — *themis*, 601.
 — *thetis*, 614.
 — *thoas*, 605.
 — *tholus*, 625.
 — **triacontadactylus**, 555.
- Actinocrinus tricornis**, 468, 470.
 — **trijugis**, 576. (Pl. LIV, figs. 4a, b.)
 — *trinodus*, 467.
 — **tuberculosus**, 573. (Pl. LII, figs. 8a-c.)
 — *turbatus*, 375.
 — — *var. elegans*, 376.
 — *umbrosus*, 628.
 — *unicarinatus*, 557.
 — *unicornis*, 468.
 — *unispinus*, 467.
 — *urna*, 555.
 — *urnæformis*, 447.
 — *validus*, 582.
 — *ventricosus*, 593.
 — — *var. cancellatus*, 593.
 — — *var. internodius*, 593.
 — — *var. reticulatus*, 593.
 — *verneuilianus*, 450.
 — **verrucosus**, 558, 561. (Pl. LII, figs. 2a-c.)
 — *viaticus*, 555.
 — *viminalis*, 590.
 — *Wachsmuthi* (White, 1862), 559.
 — — (White, 1880), 381.
 — *Whitei*, 520, 530.
 — *Whitfieldi*, 522.
 — *Yandelli*, 441.
- Actinoidea*, 16.
Actinometra, 99, 212.
 Ad-ambulacral or side-pieces, 36, 100.
Agaricocrinus, 104, 362, 431, 481, 486, 586.
 — *americanus*, 487, 488, 489. (Pl. XLII, figs. 1a-2b.)
 — — *var. tuberosus*, 489. (Pl. XL, fig. 6; XLII, fig. 4.)
 — **bellatrema**, 506. (Pl. XLI, figs. 4a-d.)
 — — *var. major*, 507. (Pl. XLI, fig. 5.)
 — *Blairi*, 503.
 — **brevis**, 511. (Pl. XXXVIII, figs. 2a-e.)
 — **bullatus**, 489, 493. (Pl. XLI, figs. 2a-d.)
 — *chouteauensis*, 505.
 — **conicus**, 501. (Pl. XXXIX, figs. 7, 8.)
 — **convexus**, 508. (Pl. XXXVIII, figs. 1a, b.)
 — **Coreyi**, 510. (Pl. XXXIX, figs. 1a, b.)
 — *corrugatus*, 512.
 — **crassus**, 499, 500. (Pl. XXXIX, figs. 2a, b; XL, fig. 4.)
 — *decornis*, 503.
 — *dissimilis*, 488.

- Agaricocrinus elegans*, 500. (Pl. XL, figs. 3a, b.)
 — *eris*, 481.
 — *excavatus*, 489, 491. (Pl. XXXIX, figs. 3-5.)
 — *fiscellus*, 512. (Pl. XXXVIII, figs. 3a-c.)
 — *geometricus*, 508.
 — *germanus*, 505.
 — *Gorbyi*, 495.
 — *gracilis*, 513. (Pl. XLI, figs. 3a-c.)
 — *helice*, 481.
 — *indianensis*, 495.
 — *inflatus*, 502. (Pl. XLI, figs. 1a-d.)
 — *Macadamsi*, 498.
 — *nodosus*, 489, 493. (Pl. XLIII, fig. 9.)
 — *nodulosus*, 497. (Pl. XL, fig. 2; XLIII, figs. 7a, b.)
 — — var. *Macadamsi*, 498. (Pl. XXXIX, fig. 6.)
 — *ornotrema*, 506.
 — *pentagonus*, 493, 495, 509.
 — — var. *convexus*, 508.
 — *planoconvexus*, 503. (Pl. XXXVIII, figs. 6a-c.)
 — *pyramidatus*, 512. (Pl. XXXVIII, figs. 4a-5c.)
 — *Sampsoni*, 505. (Pl. XLVI, fig. 5.)
 — *splendens*, 495. (Pl. XL, figs. 1a-c.)
 — *Springeri*, 510.
 — *stellatus*, 508. (Pl. XXXVIII, figs. 7a-e.)
 — *tuberosus*, 490.
 — *Whitfieldi*, 496. (Pl. XLII, fig. 3; XLIII, figs. 8a, b.)
 — *Wortheni*, 488, 490, 493. (Pl. III, fig. 22; XXXIX, fig. 9; XL, figs. 5a-d.)
Agassizocrinus, 17, 45, 59, 145.
 "Albatross" dredgings, 28.
Allagecrinus, 28, 78, 87, 89, 92, 150, 172.
 — *Carpenteri*. (Pl. VIII, fig. 11.)
Alloerinus, 124, 265, 267, 306.
 — *Benedicti*, 308. (Pl. XXIV, figs. 8a, b.)
 — *typus*, 307. (Pl. XXIV, figs. 7a, b.)
Alloprosalloerinus, 361, 406, 414, 430.
 — *conicus*, 407, 431. (Pl. XLII, figs. 14a-c.)
 — *depressus*, 407.
 — *euconus*, 407, 430.
 — *Gurleyi*, 407.
 Alternate arrangement of parts below radials, 60.
 Ambulacra, 35, 99, 100, 104, 120, 155.
 — of *Camerata*, 100, 107, 114.
 — of *Fistulata*, 99.
 — of *Ichthyocrinidae*, 101, 123.
 — of *Larviformia*, 101.
 — of Recent *Crinoids*, 101.
 Ambulacral canal, 100.
 Ambulacral plates, 35, 101, 119.
 Ambulacral skeleton. (Pl. IV, fig. 9; Pl. V, figs. 1 and 10.)
 Ambulacral vessels, 36.
Americanus group, 686.
Amphora, 586.
Amphoracrinus, 85, 454, 483, 486, 550, 554, 586.
 — *americanus*, 488.
 — *bellatrema*, 506.
 — *concavus*, 482.
 — *divergens*, 588. (Pl. LXII, figs. 5-10.)
 — — var. *multiramosus*, 588, 590.
 — *excavatus*, 491.
 — *Gilbertsoni*, 587.
 — *inflatus* (*Hall, 1860*), 591.
 — *inflatus* (*Hall, 1861*), 502.
 — *jerseyensis*, 587.
 — *planobasilis*, 588.
 — *planoconvexus*, 503.
 — *quadrispinus*, 588.
 — *spinobrachiatus*, 591. (Pl. LXII, figs. 1-4.)
 — *subturbinatus*, 466.
 — *viminalis*, 587, 590. (Pl. LIV, fig. 8.)
 Anal plates, 17, 33, 105, 124, 139, 147, 165, 364.
 — development of, 131.
 — special or first (Pl. X), 34, 125, 147.
 Anal tube, 35, 134.
 — abnormal growths of, 135. (Pl. IV, figs. 9-17.)
 An-ambulacral plates, 35.
 Anchylosis, 37.
Ancyrocrinus, 45, 50.
Anisocrinus, 77.
Anomalocrinus, 41, 57, 67, 71, 78, 116, 130, 158.
 — *caponiformis*, 746.
Antedon, 82, 147, 153.
 — Pentacrinoid larva of, 152. (Pl. VI, figs. 13-15.)
 — *regalis*, 107.
 — *rosacea*, 64. (Pl. VI, figs. 18, 19.)

- Anthemocrinus**, 77, 215.
Anus, 21, 35, 124, 134, 139, 155.
 — of **Carabocrinus**, 137.
 — of **Cupressocrinus**, 137.
 — of **Cyathocrinus**, 137.
 — of **Haplocrinus**, 94, 137.
 — of **Hyocrinus**, 94.
 — of **Ichthyocrinus**, 138.
 — of **Pisocrinus**, 136.
 — of **Poteriocrinus**, 137.
 — of **Symbathocrinus**, 137.
 — covered by a Gasteropod, 240, 566, 704, 793.
Aorocrinus, 362, 470, 487, 547.
 — **canaliculatus**, 475. (Pl. XLV, figs. 6a, b.)
 — **Cassedayi**, 483. (Pl. XLII, figs. 11a-12.)
 — **conceavus**, 482. (Pl. XLII, figs. 13a-c.)
 — **elegans**, 480.
 — **helice**, 481. (Pl. XLV, fig. 2, 5.)
 — **immaturus**, 471.
 — **parvibasis**, 473, 477. (Pl. XLV, figs. 3a, b.)
 — **parvus**, 477. (Pl. XLV, figs. 11a, b.)
 — **radiatus**, 472. (Pl. XLV, fig. 1.)
 — **spinosulus**, 478, 481. (Pl. XLIII, fig. 4; XLIV, figs. 8a, b.)
 — **subaculeatus**, 476. (Pl. XLV, figs. 7a, b.)
Apiocrinidae, 53, 59, 65, 117.
Apiocrinus, 13, 40, 60, 69, 117, 152.
 — **roissyanus**, 24, 117.
Archæocrinus, 119, 175, 215, 249, 253.
 — **desideratus**, 257. (Pl. X, figs. 4a, b.)
 — **lacunosus**, 254, 255. (Pl. X, fig. 1.)
 — **marginatus**, 275.
 — **microbasalis**, 256. (Pl. X, figs. 2a-c.)
 — **priscus**, 278.
 — **pyriformis**, 255. (Pl. X, figs. 3a, b.)
 — **sculptus**, 251.
Armlets, 34, 82, 160.
Arm openings, 36, 86.
Arm plates, or "free brachials," 33, 73.
Arms, 33, 73, 88, 155.
 — biserial, 34, 78, 155, 161.
 — uniserial, 34, 78, 155.
 — paired, 86.
 — commence at, 69.
 — mobility and mode of union, 87, 155.
 — mode of branching, 75, 78, 86, 155, 161, 364.
Arthracantha, 741, 747.
Arthracantha depressa, 751. (Pl. LXXVI, figs. 3a, b.)
 — **ithacensis**, 747, 749. (Pl. LXXVI, figs. 1a-c.)
 — **punctobrachiata**, 750, 752. (Pl. LXXVI, figs. 2a, b.)
Articles brachiaux, 17.
Articulata (W. and Sp.), 26, 33, 149, 152, 154, 169.
 — (J. S. Miller), 13, 152.
 — (Joh. Müller), 15, 152.
 — (Zittel), 23.
Articulation, 37, 87.
Articulosa, 153.
Asteria, 12.
Asteroblastus, 146.
Asterocrinus (*Minster*), 292.
Asterocrinus (*Lyon*), 292, 791, 793.
 — **capitalis**, 794.
 — **coronarius**, 795.
Astracrinoidea, 16.
Astrocrinites (*Cumberland*), 292.
Astrocrinites (*Conrad*), 292.
 — **pachydactylus**, 296.
Astrocrinus (*Ether. and Carp.*), 292.
Astropodia, 647.
Astyliida, 16.
Astylocrinus, 17.
Astylocrinidae, 172.
Asymmetry, 146.
Atelestocrinus, 132, 148, 159.
Aulocrinus, 138.
 — **Agassizi**, 138. (Pl. VII, fig. 9.)
Axial canal, 33, 36, 45, 100, 140.
Axial cords, 36.
Axillaries, 34.
Baerocrinus, 72, 131, 148, 158.
Balanocrinus, 207.
 — **sculptus**, 208.
Barrandeocrinus, 362, 484, 485.
 — **sceptrum**, 485. (Pl. VIII, fig. 1.)
Barycrinus, 41, 45, 82, 132, 160.
Basalia, 15.
Basals, 15, 17, 27, 33, 52.
 — ankylosis of, 57.
 — evolution of different, 54-56.
 — inferior face, 158.
 — orientation of, 57, 153.
 — orientation in Blastoids, 57, 153.
 — outer face, 158.
 — upper face, 37.

- Base, 33, 52, 66, 152.
 — bipartite, 54, 56.
 — hexagonal, 165, 363.
 — pentagonal, 165, 645.
 — quadripartite, 54, 56.
 — tripartite, 54, 56.
Bathycrinus, 41, 63, 142.
 — *aldrichensis*, 65. (Pl. VI, fig. 10.)
Batocrinidæ, 79, 86, 124, 165, 170, 361.
Batocrinites, 77, 86, 361, 366.
Batocrinus, 77, 109, 115, 120, 364, 366, 413, 554.
 — *abscissus*, 431.
 — *æquabilis*, 369.
 — *æqualis*, 371. (Pl. XXVIII, figs. 5, 6.)
 — *æquibrachiatus*, 440.
 — — var. *alatus*, 441.
 — *agnatus*, 451.
 — *altiusculus*, 409.
 — *andrewsianus*, 433.
 — *aspratilis*, 380.
 — *asteriscus*, 441.
 — *bisbrachiatus*, 409.
 — *biturbinatus*, 427.
 — *Blairi*, 401.
 — *boonvillensis*, 422.
 — *bulbosus*, 444.
 — **Calvini**, 373. (Pl. XLVI, figs. 8a, b.)
 — *calyculoides*, 395.
 — *calyculus* (indeterminable).
 — **cantonensis**, 383. (Pl. XXVII, figs. 7a, b.)
 — *carica*, 448.
 — *cassedayanus*, 442.
 — *clavigerus* (indeterminable).
 — *cloelia*, 398.
 — *Christyi*, 409.
 — **clypeatus**, 380. (Pl. XXVII, figs. 8a-e.)
 — *comparilis*, 380.
 — *corbulis*, 399.
 — *crawfordsvillensis*, 417.
 — *Davisi*, 424.
 — *decoris*, 420.
 — *discoideus*, 369.
 — *divalis*, 425.
 — *dodecadactylus*, 432.
 — *doris*, 371.
 — *euconus*, 430.
 — *facetus*, 418.
 — *formosus*, 369.
 — *gemmiformis*, 449.
 — *Gorbyi*, 426.
Batocrinus grandis, 43, 381. (Pl. XXVII, figs. 1a, b; 2a, b.)
 — *Gurleyi* (*S. A. Miller*), 422.
 — *Gurleyi* (*Rowley and Hare*), 428.
 — *Hageri*, 445.
 — **icosidactylus**, 367, 368. (Pl. XXVII, figs. 3a-c.)
 — *indianensis*, 415.
 — *inflatus*, 444.
 — *inornatus*, 380.
 — **irregularis**, 369. (Pl. XXVII, figs. 4a-c.)
 — *jucundus*, 451.
 — *Konincki*, 447.
 — *lætus*, 375.
 — *lagunculus*, 453.
 — **laura**, var. 135, 384. (Pl. XXIX, figs. 5a-d.)
 — *lepidus*, 372. (Pl. XXVIII, figs. 2, 3.)
 — *leucosia*, 401.
 — *longirostris*, 135, 442.
 — *Lovei*, 412.
 — *lyonanus*, 427.
 — **Macbridei**, 376, 378.
 — *marinus*, 439.
 — *matuta*, 396.
 — *mediocris*, 422.
 — *montgomeryensis*, 428.
 — **mundulus**, 382.
 — *Nashvillæ*, 435.
 — — var. *subtractus*, 436.
 — *neglectus*, 394.
 — *oblatus*, 431.
 — *papillatus*, 380.
 — *pistilliformis*, 437.
 — **pistillus**, 378. (Pl. XXXI, figs. 4a, b.)
 — *planodiscus*, 411.
 — **poculum**, 378.
 — *pulchellus*, 424.
 — *pyriformis*, 437.
 — **quasillus**, 372. (Pl. XXVIII, figs. 4a, b.)
 — *remibrachiatus*, 388.
 — **rotadentatus**, 374. (Pl. XLVI, fig. 7.)
 — *rotundus*, 431.
 — *scyphus*, 384.
 — *similis*, 382.
 — **sinuosus**, 385.
 — *sinuosus*, 385.
 — *spergenensis*, 419.
 — **subæqualis**, 369. (Pl. XXVIII, figs. 7a-9.)
 — *subconicus*, 430.

- Batocrinus** *Sweeti*, 428.
 — *trochiscus*, 410.
 — *tuberculatus*, 379. (Pl. XXVIII, figs. 10a, b.)
 — *turbinatus*, 375. (Pl. XXVII, figs. 5a-c.)
 — — var. *elegans*, 376. (Pl. XXVII, figs. 6a, b.)
 — *unionensis*, 424.
 — *venustus*, 431.
 — *verneuillianus*, 450.
 — *Wuchsmuthi*, 381.
 — *Whitei*, 419.
 — *Yandelli*, 441.
Belemnocrinus, 44, 57, 82, 172.
 Bilateral symmetry, 134, 148, 165.
 Biserial arms, 34, 78, 155, 161.
Blairocrinus, 552, 555.
 — *arrosus*, 577.
 — *bullatus*, 577.
 — *trijugis*, 576, 578.
 "Blake," dredgings, 28.
 Blastoidea, 12, 14, 16, 30, 144, 146, 153.
 — Cystidea and Crinoidea, 145.
Botryocrinus, 82, 132, 160.
 — *decadactylus*, 160.
Bourguetierinus, 48, 63.
 Brachials, 33, 69, 73, 76, 87.
Brachianal.
 Burlingtonensis group, 653.
Cucabocrinus, 316.
 — *glyptus*, 317.
 — — var. *intermedius*, 317.
 — *lamellosus*, 311, 320.
 — *liratus*, 319.
 — — var. *multilira*, 319.
 — *speciosus*, 323.
 — *Troosti*, 311, 316.
Cactocrinus, 85, 101, 107, 120, 550, 555, 575, 600, 626, 638.
 — pinnules of, 601.
 — *Arnoldi*, 622, 624. (Pl. LVII, figs. 4a, b.)
 — *clarus*, 612. (Pl. LVII, figs. 9, 10; LVIII, fig. 1.)
 — *cœlatus*, 618, 620. (Pl. LIX, figs. 8, 9.)
 — — var. *spinotentaculus*, 619. (Pl. LIX, fig. 10.)
 — *denticulatus*, 606. (Pl. LVII, figs. 5a, b.)
 — *ectypus*, 611. (Pl. LVI, fig. 10.)
 — *extensus*, 616. (Pl. LVII, figs. 6, 7.)
 — *fossatus*, 620. (Pl. LV, fig. 12.)
Cactocrinus *glans*, 102, 625, 628. (Pl. IV, fig. 8; LIV, figs. 5-7.)
 — *limabrachiatus*, 608. (Pl. LVIII, figs. 9, 10b.)
 — *longus*, 609. (Pl. LVII, fig. 8.)
 — *lucina*, 603. (Pl. LVI, figs. 8, 9.)
 — *multibrachiatus*, 617, 618. (Pl. LVI, figs. 6, 7; LVIII, fig. 8.)
 — *nodobrachiatus*, 622, 625. (Pl. LVII, figs. 1, 2.)
 — *obesus*, 613. (Pl. LV, figs. 9a, b.)
 — *opuseculus*, 607. (Pl. LVI, figs. 5a, b.)
 — *ornatissimus*, 621, 625. (Pl. LVII, fig. 3.)
 — *proboscidalis*, 102, 601, 603. (Pl. LVIII, figs. 3-7d.)
 — *reticulatus*, 603, 605, 607. (Pl. LVIII, figs. 2a, b.)
 — — var. *ovatus*, 606. (Pl. LVII, fig. 11.)
 — *sexarmatus*, 615. (Pl. LV, figs. 10, 11.)
 — *thalia*, 604. (Pl. LVI, fig. 2; LVII, figs. 12, 13.)
 — *thetis*, 614, 616. (Pl. LVI, figs. 3, 4.)
Calamocrinus, 28, 40, 51, 78, 99, 117.
Calathocrinus (von Meyer), 626.
Calathocrinus (*Hall*), 626, 637.
 — *althea*, 632.
 — *erodus*, 630.
 — *insculptus*, 630.
Calceocrinidæ, 57, 72, 82, 134, 148, 157, 172.
Callicrinus, 330, 335, 353.
 — *acanthinus*, 356. (Pl. LXXXIII, fig. 18.)
 — *Beachleri*, 355. (Pl. LXXXIII, figs. 14a, b.)
 — *cornutus*, 357. (Pl. LXXXIII, figs. 15-17.)
 — var. *excavatus*, 357.
 — *murchisonianus*, 358.
 — *ramifer* (?), 358.
Calpioocrinus, 52, 77.
Calypocrinidæ, 43, 165, 170, 330.
Calyx, 33.
Calyx interradialis, 105.
Camerata, 26, 33, 42, 69, 149, 151, 163.
 — analysis of families of, 170.
 — distribution of, 171.
 — sections of, 150, 163.
Camptocrinus, 741, 779.
 — *cirrifer*, 44, 780. (Pl. LXXXVI, figs. 12-13c.)

- Camptocrinus myelodaetylus**, 44, **779**. (Pl. LXXV, figs. 1-2b.)
Canaliculata, 30.
Canistrocrinus, 174.
 — *Pattersoni*, 174.
 — *Richardsoni*, 174.
Carabocrinidæ, 159, 162.
Carabocrinus, 162.
Carpocrinus, 515.
 — *simplex*, 515.
Caryocrinus, 14, 146.
Castanocrinus, 292.
Catillocrinidæ, 82, 134, 157, 172.
Catillocrinus, 45, 72, 142.
 — **Wachsmuthi**, 72. (Pl. VIII, fig. 14.)
Centrocrinus (Austin), 309, 647, 649.
Centrocrinus (W. and Sp.), 124, 207, 265, **308**.
 — *multicornis*, 309.
 — *pentaspinus*, **309**. (Pl. XXV, figs. 10a-c.)
 — *tennesseensis*, 206, 308.
 Centrodorsal; see Top stem-joint, 33.
Ceriocrinus, 133, 162.
 "Challenger" dredgings, 28; Report, 27.
 Chambered organ, 36, 100, **140**.
 Characters in classification, 108, 149, 153, 161, 166.
 Characters, in one group worthless in others, 156.
Cheirocrinus clarus, 51.
Cionacineti, 16.
 Cirri, 32, 41.
 Classification, **144**.
 — of the Austins, 15.
 — of P. H. Carpenter, 27.
 — of Chapman, 30.
 — of J. S. Müller, 13.
 — of Joh. Müller, 15.
 — of Neumayr, 29.
 — of Pictet, 17.
 — of Roemer, 16.
 — of Steinmann, 30.
 — of Wachsmuth and Springer, 25.
 — of Zittel, 23.
Clonocrinus, 292.
 Close suture, 37.
Coadunata, 13.
Coccoerinus, 90, 92, 94, 642, 645, **738**.
 — *baeca*, **739**. (Pl. LXXV, figs. 15a-c.)
 — *rosaceus*, **739**. (Pl. III, fig. 14.)
Codaster, 146.
Codiocrinus, 77.
 Cæliac canal, 100.
Cæliocrinus ventricosus. (Pl. VII, figs. 10a-b.)
Cælocrinus, 455.
 — *concavus*, 455.
 Color of specimens, 227.
 Column; see Stem, 32.
Columnida, 16.
Comastella, 16.
Comatulæ, 12, 14, 17, 50, 53, 59, 65, 70, 152.
 Compound radials, 71, 158.
Compsocrinus, 80, 147, 269, 282, 362, 365, **516**.
 — **Harrisi**, **517**. (Pl. XXI, figs. 8a, b.)
 — *miamiensis*, **518**. (Pl. XXI, figs. 7a, b.)
Conocrinus (Conocrinites), 406.
Consolidating apparatus, 114.
 Convoluted organ, 102, **142**. (Pl. V, figs. 1-12.)
Cordylocrinus, 79, 642, 645, 647, **735**.
 — *comtus*, 736.
 — *parvus*, 737.
 — *plumosus*, **737**. (Pl. LXXV, fig. 20.)
 — *ramulosus*, **737**.
 — *retarius*, 735.
Corymbocrinus, 264, 282.
 Costals, 13, 34, 71, 73, 77, 154.
Costata, 15, 23.
Cotyledonocrinus, 646, **753**.
 — *pentalobus*, 754, **775**.
 Covering plates of Ambulacra, 36, 100, 108, 112, 155.
 Crinoidea, 12, 30, 145, **169**, 172.
Cromyocrinus, 80, 123, 162.
Crotalocrinidæ, 83, 163, 164, 170.
Crotalocrinus, 46, 81.
 — *pulcher*. (Pl. VIII, fig. 2.)
 — *n. sp.* (Pl. VIII, fig. 3.)
 — *rugosus*. (Pl. VIII, fig. 4.)
 Crown, 32.
Ctenocrinus, 282, 286, 292, 294.
 — *bainbridgensis*, 297.
 — *lævis*, 301.
 — *ornatus*, 286.
 — *typus*, 294.
Culicoerinus, 79, 83, 90, 92, 486, 642, 645, **735**, **739**. (Pl. LXXV, fig. 14.)
Cupellæcrinus, 730.
 — *Buchi*, 730.

- Cupellæcrinus corrugatus*, 730.
 — *inflatus*, 731.
 — *lævis*, 731.
 — *magnificus*, 731.
 — *pentagonalis*, 731.
 — *roseiformis*, 731.
 — *stellatus*, 731.
 — *striatus*, 731.
Cupressocrinus, 45, 70, 87, 114, 137, 141, 158, 172.
Cupulocrinus, 175.
Cyathocrinacea, 29.
Cyathocrinidæ, 142, 155, 162, 172.
 — *of Bather*, 159.
 — *of Roemer*, 17.
Cyathocrinus, 13, 17, 45, 77, 95, 98, 101, 111, 114, 128, 130, 159.
 — marginal plates of, 97, 175.
 — orals of, 95.
 — *alutaceus*, 96, 162. (Pl. III, figs. 6, 7.)
 — *brevisacculus*, 96, 137. (Pl. III, fig. 2; VII, figs. 12a, b.)
 — *fasciatus*, 288.
 — *Gilesi*, 95, 97. (Pl. III, figs. 1a, b.)
 — *lævis*. (Pl. III, fig. 8.)
 — *malvaceus*, 97.
 — *multibrachiatus*, 96. (Pl. III, fig. 4.)
 — *nodosus*, 96, 137. (Pl. III, fig. 3; VII, figs. 11a, b.)
 — *planus*, 17.
 — *protuberans*, 793.
 — *ramosus*, 162.
 — *tuberculatus*, 17.
 — *waldronensis*, 192.
Cylicocrinus, 485.
 — *canaliculatus*, 485.
Cyphocrinus, 200.
 — *Gorbyi*, 201.
Cystidea, 12, 16, 30, 144, 146, 148.
Cysts, 43, 502.
Cytocrinus, 292, 294.
 — *lævis*, 301.
Decadocrinidæ, 159.
Decadocrinus grandis, 138. (Pl. VII, figs. 4, 5.)
Deltoid pieces, 115.
Dendrocrinidæ, 159.
Dendrocrinus, 71, 78, 126, 128, 132, 159.
 — *Casei*, 128.
Desmidocrinus, 79, 280, 362, 515.
Diabolocrinus, 215, 249, 262.
 — *hieroglyphicus*, 252. (Pl. X, figs. 5a-c.)
 — *perplexus*, 250. (Pl. XI, figs. 1a, b.)
 — *vesperalis*, 251. (Pl. XI, figs. 1c, d.)
Diamenocrinus, 80, 215, 219.
Dichoerinus, 42, 44, 77, 79, 81, 83, 646, 741, 753, 779, 781, 804.
 — *angustus*, 768. (Pl. LXXVI, fig. 11.)
 — *Blairi*, 778. (Pl. LXXV, fig. 3.)
 — *chesterensis*, 802.
 — *cinctus*, 764. (Pl. LXXV, fig. 5; LXXVII, figs. 4a-c.)
 — *constrictus*, 788, 791.
 — *conus*, 770. (Pl. LXXV, fig. 6.)
 — *cornigerus*, 754, 783.
 — *coxanus*, 763. (Pl. LXXVI, fig. 9.)
 — *crassitestus*, 769. (Pl. LXXVI, figs. 6a-c.)
 — *crassus*, 801.
 — *delicatus*, 44, 766, 767. (Pl. LXXVII, fig. 13.)
 — *dichotomus*, 777.
 — *elegans* (*Lyon and Cass.*), 786.
 — *expansus* (*M. and W.*), 756.
 — *ficus*, 774. (Pl. LXXVIII, figs. 16a, b.)
 — *fusiformis*, 754.
 — *hamiltonensis*, 772. (Pl. LXXVI, fig. 10.)
 — *Humburgi*, 777.
 — *Huntsvillæ*, 773. (Pl. LXXV, fig. 4.)
 — *inornatus*, 44, 377, 770. (Pl. LXXVII, figs. 12a, b.)
 — *lachrymosus*, 103, 754. (Pl. LXXVII, figs. 2a-c.)
 — *lævis*, 765, 768. (Pl. LXXVII, figs. 7a-c.)
 — *lineatus*, 761, 763. (Pl. LXXVI, figs. 4a-c.)
 — *liratus*, 759. (Pl. LXXVI, fig. 8; LXXVII, figs. 3a, b.)
 — *oblongus*, 759. (Pl. LXXVII, fig. 9.)
 — *ornatus*, 762, 763. (Pl. LXXVII, fig. 6.)
 — *ovatus*, 760. (Pl. LXXVI, fig. 7; LXXVII, figs. 8a, b.)
 — *parvulus*, 44, 778.
 — *pendens*, 774, 775. (Pl. LXXVIII, fig. 15.)
 — *pentalobus*, 775. (Pl. LXXVIII, figs. 11a-c.)

- Dichocrinus pisum*, 763. (Pl. LXXVI, fig. 5; LXXVII, fig. 10.)
 — *plicatus*, 758. (Pl. LXXVII, figs. 5a, b.)
 — *pocillum*, 767.
 — *polydactylus*, 103, 756. (Pl. LXXVII, figs. 1a, b.)
 — *radiatus*, 754.
 — *scitulus*, 767, 772. (Pl. LXXVIII, figs. 13a-14.)
 — *sculptus* (*Lyon and Cass.*), 762.
 — *sexlobatus*, 754, 784.
 — *simplex*, 790.
 — *striatus*, 757. (Pl. LXXVII, figs. 11a, b.)
 — *subspinulosus*, 754.
 — *superstes*, 766. (Pl. LXXVI, fig. 12.)
 — *symmetricus*, 786.
 — *Ulrichi*, 772.
Dicyclie, 33.
Dicyclie Crinoids, 54, 58, 60, 67.
Dicyclia, 59, 157, 165.
Dimerocrinus, 189, 190.
 — *aptilis*, 192.
 — *decadactylus*, 191.
 — *icosidactylus*, 191.
 — *liliiformis*, 192.
 — *oligoptilis*, 192.
 — *waldronensis*, 192.
Discoidens group, 710, 713.
Disk, 29, 35, 105.
Disk ambulacra, 35, 154.
Discoveries of specimens, 19.
Distal, 37.
Distichals (*Distichalia*), 15, 34, 71, 78, 97, 100, 108.
Distribution, geological and geographical, 171, 188, 265, 363, 551, 643, 742, 803.
Dizygocrinus, 362, 367, 374, 413.
 — *andrewsianus*, 433. (Pl. XXIX, figs. 2a-d.)
 — *biturbinatus*, 427, 430. (Pl. XXXIII, fig. 9.)
 — *cantonensis*, 423. (Pl. XXXIII, figs. 8a, b.)
 — *crawfordsvillensis*, 417.
 — *decoris*, 420. (Pl. XXXV, fig. 6.)
 — *dodecadactylus*, 432. (Pl. XXIX, figs. 1a-c.)
 — *euconus*, 413, 430. (Pl. XXXV, figs. 7a, b.)
 — var. *abscissus*, 431. (Pl. XLVI, fig. 9.)
Dizygocrinus facetus, 418. (Pl. XXXIII, fig. 12.)
 — *Gorbyi*, 426.
 — *Gurleyi*, 422. (Pl. XXXIV, fig. 19.)
 — *indianensis*, 413, 415, 417. (Pl. XXXIII, figs. 6a, b; XXXV, fig. 5.)
 — var. *simplex*, 416. (Pl. XXXIII, fig. 7.)
 — *montgomeryensis*, 428. (Pl. XXXIII, figs. 3, 4; XLVI, fig. 10.)
 — var. *unibrachiatus*, 429. (Pl. XXXIII, figs. 5a-c.)
 — *mutabilis*, 414, 429. (Pl. XXXV, figs. 8, 9, 10, 11.)
 — *originarius*, 414, 421. (Pl. XXXIII, figs. 1a, b; XXXV, figs. 14, 15.)
 — var. *adultus*, 414, 422.
 — *rotundus*, 431, 432. (Pl. XXIX, figs. 3a-4.)
 — *unionensis*, 424. (Pl. XXXV, figs. 16-20.)
 — var. *divalis*, 425. (Pl. XXXV, figs. 21-24.)
 — *Whitei*, 419, 421. (Pl. XXXIII, figs. 10a, b, 11.)
 — *didactylus*, 420. (Pl. XXXV, figs. 12, 13.)
Dolatocrinites, 264, 304.
Dolatocrinus, 77, 122, 124, 265, 307, 310, 311.
 — *canadensis*, 315. (Pl. XXV, figs. 7a, b.)
 — *excavatus*, 321. (Pl. XXV, fig. 1; XXVI, figs. 7, 8.)
 — *glyptus*, 317, 318. (Pl. XXVI, figs. 2a, b.)
 — *icosidactylus*, 319. (Pl. XXVI, figs. 5a-d.)
 — *lacus*, 311. (Pl. XXVI, figs. 6a-c.)
 — *liratus*, 319. (Pl. XXVI, fig. 3.)
 — var. *multilira*, 319.
 — *Lyoni*, 314. (Pl. XXV, figs. 6a-d.)
 — *major*, 322. (Pl. XXV, fig. 5.)
 — *Marshi*, 312. (Pl. XXVI, fig. 1a-d.)
 — var. *hamiltonensis*, 314. (Pl. XXV, figs. 2a, b.)
 — *ornatus*, 317.
 — *speciosus*, 323. (Pl. XXV, figs. 4a, b.)
 — *triadactylus*, 316. (Pl. XXVI, figs. 4a-d.)
 — *tuberculatus*, 324. (Pl. XXV, fig. 3.)
Dorsal cup, 33, 150.
Dorsocentral, 33, 49, 51.

- Dorycerinus**, 102, 107, 121, 362, 414, 454, 484, 487, 554, 586. (Pl. IV, fig. 5.)
 — *amœnus*, 477.
 — *canaliculatus*, 455, 475.
 — *concavus*, 455, 482.
 — *confragosus*, 401.
 — **cornigerus**, 458, 460. (Pl. XLII, figs. 5, 6; XLIII, fig. 5; XLIV, figs. 6, 7.)
 — *desideratus*, 463.
 — *elegans*, 480.
 — **Gouldi**, 456. (Pl. XLIII, figs. 2, 3; XLIV, figs. 4, 5.)
 — *immaturus*, 471.
 — *inflatus*, 468, 470.
 — *intermedius*, 461. (Pl. XLIV, fig. 1.)
 — *Kelloggi*, 478.
 — *lineatus*, 468.
 — *mississippiensis*, 455. (Pl. III, fig. 20; XLIII, fig. 1; XLIV, figs. 2, 3.)
 — — var. *spiniger*, 455.
 — *missouriensis*, 463. (Pl. XLIII, fig. 6; XLV, figs. 13a-14.)
 — *parvibasis*, 473.
 — *parvus*, 477, 479.
 — *pendens*, 468.
 — *quinquelobus*, 460. (Pl. XLII, figs. 7-9.)
 — — var. *intermedius*, 461.
 — *radiatus*, 472.
 — **Roemeri**, 464. (Pl. XLV, figs. 15a, b.)
 — *spinosulus*, 478.
 — *subaculeatus*, 476.
 — *subturbatus*, 466. (Pl. XLII, figs. 10a, b.)
 — *tricornis*, 468.
 — *unicornis*, 468. (Pl. XLV, figs. 8a-10.)
 — *unispina*, 467. (Pl. XLV, fig. 12.)
Ectenocrinus, 41, 129, 133.
 — *simplex*, 71.
Edriocrinus, basals of, 59, 145.
Edwardsoocrinus, 647.
Eleutheroocrinus, 145.
Emedullata, 30.
Enerinidæ, 87, 117, 162.
Enerinites, 12, 647.
Encrinus, 11, 14, 63, 69, 80, 127, 133, 152, 160, 162.
 — *liliiformis*, 11, 80, 140.
 — *gracilis*, 80.
Entrochites, 11.
Epactocrinus grandis, 82.
Epascocrinoidea, 29, 148.
Epizygal, 34, 81.
Eretmocrinus, 361, 367, 375, 380, 385, 414, 554.
 — *adultus*, 422.
 — *calyculoides*, 395. (Pl. XXXIV, figs. 1a-4.)
 — *nodosus*, 396. (Pl. XXXIV, figs. 6, 7, 8.)
 — *carica*, 448.
 — *clio*, 375, 393, 394. (Pl. XXXVI, figs. 2a, b; XXXVII, figs. 9a, b.)
 — *clælia*, 398. (Pl. XXXVI, figs. 4a, b.)
 — *corbulis*, 399, 401. (Pl. XXXVI, figs. 5a-6.)
 — *coronatus*, 403. (Pl. III, fig. 18; XXXVII, figs. 7a-c.)
 — *depressus*, 392. (Pl. XXXVI, figs. 11a, b.)
 — *gemmiformis*, 449.
 — *granuliferus*, 390. (Pl. XXXIV, figs. 5a-c.)
 — *intermedius*, 404. (Pl. XXXIII, figs. 2a-c.)
 — *Konincki*, 447.
 — *leucosia*, 401. (Pl. XXXVI, figs. 7a-c.)
 — *lyonanus*, 386.
 — *magnificus*, 382, 386. (Pl. XXXVII, fig. 3.)
 — *matuta*, 396. (Pl. XXXVII, figs. 6a-c.)
 — — var. *attenuata*, 397.
 — *minor*, 391. (Pl. XXXVI, figs. 10a, b.)
 — *neglectus*, 394. (Pl. XXXVI, fig. 3.)
 — *originarius*, 422.
 — *prægravis*, 405. (Pl. XXXIV, figs. 9, 10.)
 — *ramulosus*, 387, 390. (Pl. XXXVII, figs. 4a-5d.)
 — *remibrachiatus*, 388. (Pl. XXXVII, figs. 2a, b.)
 — — var. *expansus*, 390. (Pl. XXXVI, fig. 1; XXXVII, figs. 1a, b; XLIV, fig. 9.)
 — *rugosus*, 402. (Pl. XXXVI, figs. 9a-c.)
 — *varsoviensis*, 421.
 — *verneuillianus*, 450.
Erisocrinus, 24, 80, 123, 127, 133, 162.
Eucalyptocrinidæ, 330.
Eucalyptocrinus, 209, 330, 332, 353.
 — *armosus*, 335.
 — *chicagoensis*, 342.
 — *cælatus*, 336, 339. (Pl. LXXXIII, figs. 5-7.)
 — *cælatus* (Roemer, not Hall), 341.
 — *conicus*, 335.
 — *constrictus*, 342.

- Eucalyptocrinus cornutus**, 335, 357.
 — **crassus**, 51, **342**, 345. (Pl. LXXXI, figs. 1-15.)
 — **decorus** (*Hall*), 336.
 — **decorus** (*Phillips*), 337. (Pl. LXXXII, fig. 15.)
 — **depressus**, **349**. (Pl. LXXXIII, figs. 2, 4b.)
 — **Egani**, **352**. (Pl. LXXXII, figs. 11, 12.)
 — **ellipticus**, 335.
 — **Elrodi**, 336, **339**, 340. (Pl. LXXXI, figs. 7a-13.)
 — **excavatus**, 335.
 — **extensus**, 335.
 — **gibbosus**, 335.
 — **Goldfussi**, 335.
 — **Gorbyi**, 348.
 — **inconspectus**, **346**. (Pl. LXXXIII, figs. 1, 2.)
 — **lævis**, 335.
 — **Lindahli**, **347**. (Pl. LXXXII, fig. 9.)
 — **magnus**, **348**. (Pl. LXXXII, figs. 7, 8.)
 — **muralis**, 337.
 — **nashvillæ**, 335.
 — **obconicus**, **353**. (Pl. LXXXIII, fig. 13.)
 — **ornatus**, **340**. (Pl. LXXXII, fig. 10.)
 — **ovalis**, **344**. (Pl. LXXXII, figs. 1-6.)
 — **ovatus** (*Hall*), 344.
 — **papulosus**, 336.
 — **Phillipsi**, 335.
 — **proboscidalis**, **352**. (Pl. LXXXII, fig. 14.)
 — **ramifer**, 335, 358.
 — **rosaceus**, 331, 334.
 — **rotundus**, **350**.
 — **splendidus**, **350**.
 — **subglobosus**, 339.
 — **tennesseæ**, 335.
 — **tuberculatus**, **337**. (Pl. LXXXIII, figs. 8-10.)
 — **turbinatus**, **351**. (Pl. LXXXII, fig. 13.)
 — **ventricosus**, 336, **341**. (Pl. LXXXIII, figs. 11, 12.)
 — **Wortheni**, 347.
Eucladocrinus, 76, 84, 101, 642, 646, 648, 665, **719**.
 — **millebrachiatus**, 104, **720**, 725. (Pl. LXXXIII, fig. 1; LXXIV, figs. 2-9.)
 — — **var. immaturus**, **722**. (Pl. LXXXIII, figs. 2, 3.)
 — **montanensis**, 719, **723**. (Pl. LXXII, fig. 5.)
Eucladocrinus pleuroviminus, 713, **724**, 726. (Pl. LXXXIII, fig. 4; LXXIV, fig. 1.)
 — **prænuntius**, **726**. (Pl. LXXXIII, fig. 5.)
 — **tuberosus**, **728**. (Pl. LXXXII, figs. 3-4c.)
Eucrinoidea, 23.
Eucrinus, 189, 192.
 — **interradialis**, 192.
 — **lævis**, 192.
 — **minor**, 192.
 — **ornatus**, 192.
 — **quingularis**, 192.
 — **speciosus**, 192.
 — **venustus**, 192.
Eugeniocrinidæ, 24, 54.
Eugeniocrinites (*J. S. Miller*), 13.
Eugeniocrinites (*Heisinger*), 14.
Eupachyrcrinus, 24, 45, 80, 123, 160, 162.
Euryale, 12.
Euspirocrinidæ, 159.
Euspirocrinus spiralis, 96, 132. (Pl. III, fig. 5.)
Eutrochoocrinus, 361, 367, 408, 414.
 — **Christyi**, **409**. (Pl. III, fig. 21; IV, fig. 7; XXIX, fig. 6; XXXII, figs. 1a-c.)
 — — **var. trochiscus**, **410**. (Pl. XXXII, fig. 3.)
 — **Lovei**, **412**. (Pl. XXIX, fig. 7; XXXII, figs. 2a, b.)
 — **planodiscus**, **411**. (Pl. XXXII, figs. 4a, b.)
 Evolution of Crinoids, 166.
Extracrinus, 53, 61, 63, 65.
Fistulata (*W. and Sp.*), 26, 35, 114, 147, 150, 153, 161, **169**.
Fistulata (*Bather*), 157.
Fistulata (*Chapman*), 30.
 Fixed Brachials, 33.
 Food groove, 36, 100.
Forbesiocrinus, 77.
 — **Agassizi**, 77.
 — **nobilis**, 77. (Pl. VIII, figs. 6a-c.)
 — **Pratteni**, 294.
 Free Brachials, 33.
Gasterocomidæ, 141, 157, 172.
Gaurocrinus, 175, 197.
 — **angularis**, 199.
 — **cognatus**, 180.
 — **magnificus**, 177.
 — **Nealli**, 179.
 — **splendens**, 198.
Gazacrinus, 202, 204.

- Gazacrinus inornatus*, 203.
 Genital canal, 36, 100.
Gennæocrinus, 362, 484, **547**, 554.
 — *Cassedayi*, 483.
 — *cornigerus*, 549.
 — *eucharis*, 549. (Pl. XXXIV, fig. 14.)
 — *kentuckiensis*, 547, **548**, 549. (Pl. XXXIV, figs. 11, 12, 13.)
Geocrinus, 519.
 Geological and geographical distribution, 171, 188, 265, 363, 551, 643, 742, 803.
 — of the Camerata, 163.
 Geological range of Palæozoic Crinoids, 172.
 Geological record, 167.
Gilbertocrinus, 86, 122, 215, **233**.
 — *calcaratus*, 236. (Pl. XV, fig. 5.)
 — *dispanus*, **240**. (Pl. XV, figs. 2a-d.)
 — *fiscellus*, 235, 238, **245**. (Pl. XVII, figs. 2a-d.)
 — *obovatus*, 238, **241**. (Pl. XVII, figs. 4a, b.)
 — *reticulatus*, **244**. (Pl. XVII, figs. 1a, b.)
 — *spinigerus*, 235, **247**. (Pl. XV, figs. 3a-c.)
 — *stellaris*, 219, 236. (Pl. XV, fig. 4.)
 — *tenuiradiatus*, **246**. (Pl. XVII, fig. 3.)
 — *tuberculosus*, **243**. (Pl. XVII, figs. 5a-c.)
 — *tuberosus*, **239**, 793. (Pl. XV, figs. 1a, b; XVI, figs. 1-6; XVII, fig. 6.)
 — *typus*, **242**. (Pl. XIV, figs. 1, 2, 3; XVII, figs. 7a, b.)
Gissocrinus, 159.
Glyptaster, 175, 189.
 — *armosus*, 211.
 — *brachiatus*, 191, 195.
 — *Egani*, 192.
 — *inornatus*, 193.
 — *occidentalis*, 193.
 — var. *in crebescens*, 195.
 — *pentangularis*, 192.
Glyptasteridæ, 189.
Glyptocrinidæ, 175, 189, 267.
Glyptocrinus, 44, 66, 79, 84, 113, 117, 147, 174, 197, 209, 264, **267**, 294, 516, 521.
 — *angularis*, 199, 269.
 — *argutus*, 269, 280.
 — *armosus*, 211, 269.
 — *Baeri*, 177, 185, 269.
 — *basilis*, 269.
 — *Carleyi*, 269, 282.
Glyptocrinus cognatus, 177, 269.
 — *decadactylus*, 84, 269, **270**. (Pl. XX, figs. 4a-e; XXI, figs. 4a, b.)
 — *Dyeri*, 84, **271**. (Pl. XX, figs. 1a-c; XXI, 3a-f, 6.)
 — *Dyeri*, var. *subglobosus*, 271.
 — *expansus*, 269.
 — *fimbriatus*, 269.
 — *Fornshelli*, 45, 66, 175, **267**. (Pl. XX, fig. 3; XXI, fig. 5.)
 — *globularis*, 269.
 — *gracilis*, 269.
 — *Harrisi*, 269, 282, 517.
 — *lacunosus*, 255, 269.
 — *libanus*, 269.
 — *marginatus*, 254, **275**. (Pl. XX, fig. 2.)
 — *miamiensis*, 269, 517.
 — *nobilis*, 212, 269.
 — *Onealli*, 177, 179, 269.
 — *ornatus*, 120, **274**. (Pl. XX, figs. 6a, b.)
 — *parvus*, 175, 199, 269.
 — *Pattersoni*, 174, 269.
 — *plumosus*, 269.
 — *priscus*, 198, 269, 278.
 — *quinquepartitus*, 269.
 — *ramulosus*, **273**. (Pl. XX, figs. 5a, b.)
 — *Richardsoni*, 174, 177, 271.
 — *sculptus*, 260, 269.
 — *Shafferi*, **272**.
 — var. *germanus*, 272.
 — *siphonatus*, 211, 269.
 — *subglobosus*, 174, **271**.
 — *subnodosus*, 259, 269.
Gnorimocrinus, 138.
Goniasteroidocrinus, 234, 237.
 — *fiscellus*, 245.
 — *lyonanus*, 240.
 — *obovatus*, 241.
 — *reticulatus*, 244.
 — *spinigerus*, 247.
 — *tenuiradiatus*, 246.
 — *tuberculosus*, 243.
 — *tuberosus*, 239.
 — *typus*, 242.
Graphiocrinus, 44, 60, 80, 128, 130, 133.
Graphiocrinus encrinoides, 80.
 Growth in Individual, 79, 83, 536, 629, 652, 654, 680, 804.
Guettardierinus, 24, 61, 69, 117.
 Habits of Crinoids, 48, 50.
Habrocrinus, 79, 362, 515.

- Habrocrinus ornatus*, 118, 120.
Hadrocrinus, 77, 265, 267, **327**.
 — *discus*, **328**. (Pl. XXIV, fig. 1.)
 — *pentagonus*, 327.
 — *plenissimus*, **328**. (Pl. XXIV, figs. 2a, b.)
Haplocrinacea, 29.
Haplocrinus, 29, 72, 89, 91, 95, 97, 137, 172.
 — *mespiliformis*, 89, 92. (Pl. III, figs. 12a, b.)
 Hemisphericus group, **703**.
Herpetocrinus, 44, 158.
Heterocrinidæ, 82, 172.
Heterocrinus, 41, 67, 71, 82, 129, 157, 779.
 — *bellevillensis*, 131.
Hexacrinidæ, 83, 106, 163, 165, 170, 645, **741**, 742, 803.
Hexacrinites, see *Hexacrinidæ*.
Hexacrinus, 79, 647, 741, **744**, 747.
 — *Leai*, **746**. (Pl. LXXVIII, figs. 12a, b.)
 — *melo*, 745.
 — *occidentalis*, **745**. (Pl. LXXVIII, fig. 10.)
 Hexagonal base, 165, 363.
 Historical, 11.
Holopus, 14, 94, 142.
Homocrinus, 45, 78, 131, 159, 161.
 — *scoparius*, 45.
Hoplocrinus, 71.
Hyboerinidæ, 57, 82, 116, 147, 162, 172.
Hyboerinus, 67, 71, 129, 133, 162.
Hybocystis, 71, 146.
Hydreionocrinus, 80.
Hyocrinus, 58, 78, 94, 99, 118.
 — *bethellianus*. (Pl. III, fig. 10.)
Hypanthocrinus, 332, 335.
 — *decorus*, 336.
Hypascocrinoidea, 29, 148.
Hyptioerinus, 188, **200**.
 — *typus*, **201**. (Pl. XIX, figs. 6a-c.)
 Hypozygal joints, 34, 81.
Hystericrinus, 747.
 — *Carpenteri*, 750.
Ichthyocrinacea, 29.
Ichthyocrinidæ, 40, 58, 64, 87, 113, 123, 152, 158, 172.
Ichthyocrinus, 77, 147, 152.
Icosidactylocrinites, 268.
Idiocrinus, 188, **202**.
 — *elongatus*, 203, 206. (Pl. XVIII, figs. 8a-c.)
Idiocrinus immaturus, **206**. (Pl. XVIII, figs. 10a-c.)
 — *tennesseensis*, **206**. (Pl. XVIII, fig. 11.)
 — *ventricosus*, 203, **205**. (Pl. III, fig. 15; XVIII, figs. 9a, b.)
Impinnata, 152, **169**, 172.
Inadunata, 26, 33, 35, 147, 150, **156**, 169.
Inarticulata, 13.
 Inferradials, 33, 71, 154.
 Infrabasals, 26, 33, **52**, 53, 61.
 — anchylosis of, 59.
 — of *Agassizocrinus*, 59.
 — of the *Apioerinidæ*, 60.
 — of *Comatulæ*, 53, 64.
 — of *Cupressocrinus*, 59.
 — of *Extracrinus*, 53, 61.
 — of the *Fistulata*, 58.
 — of the *Ichthyocrinidæ*, 58, 64.
 — of *Millericrinus*, 53, 61.
 — of *Stemmatocrinus*, 59.
 Inner floor of tegmen. (Pl. V, figs. 13-17.)
 Interambulacra, **34**, 36, 105.
 Interaxillaries, **35**.
 Interbrachials, **34**, 105.
 Interdistichals, 15, **35**, 105.
 Internal cavity, 106, 120, **140**.
 Internodal joints and internodes, **33**, 40, 155.
 Interpalmar, 15, **35**, 105.
 Interradial plates, 15, **34**, 105, 646.
 — of *Cyathocrinus*, 96, 114.
 — of the *Reteocrinidæ*, 106, 110, 174.
 — of the *Rhodocrinidæ*, 106, 217.
 — of the *Platyocrinidæ*, 646.
Iocrinus, 68, 71, 78, 126, 130, 133, 158.
Lampteroerinus, 175, 188, **207**, 211.
 — *inflatus*, 208.
 — *parvus*, 208.
 — *tennesseensis*, **208**. (Pl. XIII, figs. 10a-d.)
 Larva of *Comatulæ*, infrabasals in, 64.
 Larviformia, 26, 72, 87, **150**, 154, 162, **169**.
Lecanocrinus Billingsi, 139.
 — *macropetalus*, 139.
Lepidocentrus eifelianus, 748.
Liberia, 16.
Lobocrinus, 361, 367, 375, 385, **434**.
 — *æquibrachiatus*, 375, **440**. (Pl. XXIX, figs. 8a, b; XLVI, figs. 6a, b.)
 — var. *asteriscus*, **441**. (Pl. XXIX, figs. 9a, b.)

- Lobocrinus Hageri**, 445. (Pl. XXX, figs. 9, 10.)
 — **inflatus**, 444. (Pl. XXXIV, figs. 18a, b.)
 — **longirostris**, 442. (Pl. XXVIII, figs. 1a-e.)
 — **Nashvillæ**, 435. (Pl. XXXI, fig. 1.)
 — — var. **subtractus**, 436. (Pl. XXXI, figs. 2a, b.)
 — **pyriformis**, 437. (Pl. XXXI, figs. 3a-e.)
 — **robustus**, 436. (Pl. XXX, figs. 8a, b.)
 — **spiniferus**, 439. (Pl. XXX, figs. 11, 12.)
 — **Yandelli**, 441. (Pl. XXX, figs. 7a, b.)
 Loose suture, 37.
Lyriocrinus, 101, 215, 249, 261, 330.
 — **dactylus**, 217, 261, 262. (Pl. XI, figs. 5a-c.)
 — **melissa**, 217, 262, 263. (Pl. XI, figs. 4a-f.)
 — *sculptilis* (Hall), 251.
 — *sculptilis* (Miller), 251.
 — *sculptus*, 251, 262.
Macrocrinus, 361, 367, 446.
 — **carica**, 448. (Pl. XXXVII, fig. 8.)
 — **gemmiformis**, 449. (Pl. XXXVI, fig. 8.)
 — **Konincki**, 447.
 — **jucundus**, 451. (Pl. XXX, figs. 13, 14.)
 — **lagunculus**, 453.
 — **verneuillianus**, 102, 143, 450. (Pl. XXX, figs. 15, 16, 17, 18.)
Macrostylocrinus, 264, 285, 521.
 — **fasciatus**, 288. (Pl. XXII, fig. 13.)
 — **fusibrachiatus**, 291. (Pl. XXII, figs. 9, 10.)
 — **granulosus**, 289. (Pl. XXII, figs. 15a, b.)
 — **Meeki**, 290. (Pl. XXII, figs. 16a, b.)
 — **ornatus**, 286, 288. (Pl. XXIII, figs. 8a-c.)
 — **striatus**, 287, 288. (Pl. XXII, figs. 14a c.)
 — — var. **granulosus**, 289.
 Madreporite in Cyathocrinidæ, 35, 114, 162.
Mariacrinus, 264, 281, 292, 516.
 — **aureatus**, 285.
 — **Carleyi**, 282. (Pl. XXI, figs. 2a-c.)
 — **Harrisi**, 282, 517.
 — **granulosus**, 282.
 — **macropetalus**, 282.
 — **nobilissimus**, 295.
 — **obconicus**, 302.
 — **pachydactylus**, 296.
Mariacrinus paucidactylus, 296.
 — **plumosus**, 282, 284. (Pl. XXIII, figs. 6, 7.)
 — **ramosus**, 284.
 — *stonoliferus*, 282.
 — **Warreni**, 283. (Pl. XXII, fig. 1.)
Marsupiocrinites, 730.
Marsupiocrinus, 41, 79, 103, 111, 118, 261, 642, 645, 647, 730.
 — **cælatus**, 730.
 — **dactylus**, 262.
 — **depressus**, 118, 120, 731. (Pl. III, fig. 23.)
 — **præmaturus**, 734. (Pl. LXXII, figs. 11a, b.)
 — **radiatus**, 118. (Pl. VIII, fig. 15.)
 — **striatus**, 732. (Pl. LXXII, figs. 17, 18.)
 — **tennesseensis**, 731, 733. (Pl. LXXV, figs. 16a, b.)
 — **tentaculatus**, 733. (Pl. LXXV, figs. 19a, b.)
Marsupites, 12, 14, 17, 63, 145.
Megistocrinus, 46, 101, 120, 122, 362, 365, 519, 532, 554.
 — **abnormis**, 545, 546. (Pl. XLIX, figs. 1a-c.)
 — *brevicornis*, 533.
 — **concavus**, 543. (Pl. XLVIII, figs. 5a-c.)
 — **depressus**, 540, 541. (Pl. XLIX, figs. 2-4d.)
 — **Evansi**, 39, 119, 532, 533. (Pl. XLVII, figs. 1a-5c.)
 — — var. **crassus**, 536.
 — **Farnsworthi**, 539. (Pl. XLVIII, figs. 4a, b.)
 — *infelix*, 523, 525.
 — *Knappi*, 533.
 — **latus**, 538. (Pl. XLVIII, figs. 3a, b.)
 — *marcouanus*, 523.
 — **multidecoratus**, 542. (Pl. XLIX, fig. 6.)
 — *necis*, 524.
 — **nobilis**, 119, 537. (Pl. XLVII, figs. 6-8b; LI, fig. 8.)
 — **nodosus**, 541, 542. (Pl. XLIX, figs. 5a, b.)
 — **Ontario**, 540.
 — *parvirostris*, 533, 536.
 — *parvus*, 537.
 — *pileatus*, 544.
 — *plenus*, 533, 535.
 — **rugosus**, 542, 544. (Pl. XLVIII, figs. 6a-c.)

- Megistocrinus spinosulus**, 544. (Pl. XLVIII, figs. 1a-2.)
 — *Whitei*, 530.
Melocrinidæ, 124, 163, 170, 264.
Melocrinites, 264, 267.
Melocrinus, 76, 78, 86, 135, 264, 282, 292.
 — *æqualis*, 304.
 — *amphora*, 587.
 — *bainbridgensis*, 297. (Pl. XXII, figs. 4a-c; XXIV, fig. 5.)
 — *brevidactylus*, 294.
 — *Calvini*, 300. (Pl. XXII, fig. 6.)
 — *Clarkei*, 297.
 — *gracilis*, 298. (Pl. XXII, fig. 5.)
 — *hieroglyphicus*, 293.
 — *lævis* (Goldf.), 301.
 — *lævis* (Roemer), 302.
 — *nobilissimus*, 295. (Pl. XXIII, figs. 1, 2, 3.)
 — *nodosus*, 294.
 — *obconicus*, 302. (Pl. XXII, figs. 10a-c.)
 — *oblongus*, 300, 302. (Pl. XXII, figs. 9, 12.)
 — *obpyramidalis*, 294.
 — *pachydactylus*, 296. (Pl. XXIII, figs. 4, 5; XXIV, figs. 4a, b.)
 — *parvus*, 303. (Pl. XXII, fig. 8.)
 — *paucidactylus*, 296.
 — *Pratteni*, 294.
 — *Rœmeri*, 301. (Pl. XXII, figs. 11a, b.)
 — *sculptus*, 294.
 — *Tiffanyi*, 299. (Pl. XXII, figs. 11a, b.)
 — *Verneuli* (Hall), 294.
 — *Verneuli* (Ehlert), 294.
Meroocrinus, 68, 71, 127.
Mespilocrinus, 41, 77.
Metaocrinus, 49, 65, 67, 70.
 — *angulatus*, 65. (Pl. VI, fig. 9.)
Millerocrinus, 39, 53, 60, 65, 69.
 — *Carabœfi*. (Pl. VI, fig. 5.)
 — *icaunensis*. (Pl. VI, fig. 3.)
 — *Milleri*. Pl. VI, figs. 4a, b.)
 — *münsterensis*. (Pl. VI, fig. 6.)
 — *Orbigny*, 61. (Pl. VI, figs. 1a, b.)
 — *polydactylus*, 61. (Pl. VI, figs. 2a, b.)
 Modifications, palæontological, 61, 98.
 Monocyclic, 33.
 Monocyclic Crinoids, 54, 60, 165.
 — derivation of, 67.
Monocyclica, 53, 157.
 Morphological part, 38.
 Mouth, 21, 35, 99.
 — and Anus, 21.
 — discovery of in **Taxocrinus**, 93.
Mycocrinus, 142.
Myelodactylus, 779.
Myrtilloocrinus, 141, 158, 172.
 — *americanus*. (Pl. III, fig. 13.)
 Myzostoma cysts, 43, 502.
Nanocrinus, 159.
Nave Encrinite, 647.
Neocrinoidea, 63, 144, 148.
 Nodal joints, 33, 39.
Ohioocrinus, 41, 71, 158.
Ollocrinus, 236.
 — *fiscellus*, 245.
 — *obovatus*, 241.
 — *reticulatus*, 244.
 — *spinigerus*, 247.
 — *tenuiradiatus*, 246.
 — *tuberculosis*, 243.
 — *tuberosus*, 239.
 — *typus*, 242.
Oncocrinus, 132, 160, 162.
Onychaster attached to Crinoids, 566.
Onychocrinus, 43, 77, 138. (Pl. VI, fig. 17.)
 — infrabasals coalesced with top stem joint. (Pl. VI, fig. 11.)
 — *diversus*, 123.
 — *Ulrichi*, 123. (Pl. VI, fig. 20.)
 Orals, 26, 30, 36, 88, 155. (Pl. III, figs. 2-25.)
 — of **Antedon** larva, 89, 99.
 — of **Cyathocrinus**, 95.
 — of **Camerata**, 89.
 — of **Haploocrinus**, 91.
 — of **Larviformia**, 89, 92, 98.
 — of **Taxocrinus**, 93.
 Orientation, 37, 57, 153, 364.
 — of the axial canals, 60, 64.
 — of the basals, 56, 153.
 — of the cirri, 43, 60.
 — of the radii, 37.
 — of the stem, 45, 60, 68. (Pl. VI, figs. 1-12, 18.)
 Ornigranulus group, 701.
Orocentral, 90.
Orophocrinus, 20.
Ottawocrinus, 68.
 Outer face, 158.
 Ovarian tube, 36.
Palæocrinoidea, 25, 144, 148.

- Palæozoic Crinoids, 166.
 Palmars (Palmaria), 15, 34, 71, 73.
Parabasalia, 53.
Parisocrinus, 45, 77, 132, 159, 161.
 Parasitic growths. (Pl. IV, figs. 18-20.)
Patelloocrinus, 79, 124, 265, 307.
 — *chiasmodactylus*, 265.
 — *duplicatus*, 265.
 — *fulminatus*, 265.
 — *pinnulatus*, 265.
Pelmatozoa, 27, 144.
Pelvis, 13.
Pentacrinacea, 30.
 Pentacrinidæ, 41, 59, 65, 117, 152.
Pentacrinus, 13, 38, 45, 49, 60, 65, 69, 81, 141, 152.
 — *asterias*, 65. (Pl. VI, fig. 8.)
 — *caput-medusæ*, 11, 14, 28.
 — *europæus*, 14.
 — *naresianus*, 51.
 — *Wyville-Thomsoni*, 49.
 Pentagonal base, 165.
Pentamera, 31.
 Pentamerous symmetry, 147, 165.
Pentaphyllum, 145.
Pentremites, 14.
Periechocrinites, 46, 86, 362, 366, 519.
Periechocrinus, 46, 362, 365, 519, 520, 554.
 — *amplus*, 530.
 — *Christyi*, 522.
 — *Howardi*, 529.
 — *infelix*, 525. (Pl. L, figs. 2a-d.)
 — *marcouanus*, 523. (Pl. L, figs. 7a, b; LI, fig. 5.)
 — *moniliformis*, 520.
 — *necis*, 524. (Pl. L, figs. 1a, b.)
 — *ornatus*, 527. (Pl. L, figs. 3a, b; LI, fig. 7.)
 — *pyriformis*, 526.
 — *speciosus*, 521, 528. (Pl. L, figs. 6a, b.)
 — *tennesseensis*, 528. (Pl. L, fig. 4.)
 — *tenuidiscus*, 531. (Pl. XLVI, fig. 4; LI, fig. 6.)
 — *urniformis*, 526. (Pl. L, figs. 5a, b.)
 — *Whitei*, 530, 626. (Pl. XLVI, figs. 1-3; LI, figs. 9, 10.)
 — *Whitfieldi*, 522, 526. (Pl. LI, figs. 1-4.)
Periglyptocrinus, 80, 198, 264, 277.
 — *Billingsi*, 277. (Pl. XXI, figs. 1a, b.)
 — *priscus*, 278. (Pl. XXI, fig. 2.)
 Perisomic plates, 36, 118.
Phialocrinus, 80.
Phillipsocrinus, 294.
 Phylogenetic history represented in individual growth, 104, 166.
Physetocrinus, 85, 109, 122, 548, 550, 554, 593, 637.
 — inner floor of, 120.
 — *asper*, 596. (Pl. LXIII, figs. 7a, b.)
 — *Copei*, 598. (Pl. LXIII, fig. 5.)
 — *dilatatus*, 595. (Pl. LXIV, figs. 9, 10.)
 — *lobatus*, 599. (Pl. LXIII, figs. 8a, b.)
 — *ornatus*, 597. (Pl. IV, fig. 3; LXIII, figs. 1-4.)
 — *subventricosus*, 593.
 — *ventricosus*, 593. (Pl. IV, fig. 2; LXIII, fig. 6; LXIV, figs. 1-8b.)
Pinnastella, 16.
 Pinnata, 152, 155, 169.
 Pinnules, 34, 73, 80, 85, 155, 160.
Pisocrinus, 57, 70, 72, 136, 157, 172, 205. (Pl. XII, fig. 10.)
 — *pilula*, 90.
 Planus group, 668.
 Platycceras attached to Crinoids, 240, 566, 793, 800.
Platynerinidæ, 17, 83, 106, 124, 163, 166, 170, 642, 743, 803.
 — distribution of, 643.
Platynerinites, 647.
Platynerinus, 13, 41, 46, 48, 57, 77, 79, 83, 91, 94, 96, 102, 111, 113, 135, 149, 156, 163, 642, 644, 647, 719, 730, 738, 744, 750, 753. (Pl. IV, fig. 6.)
 — *absentivus*, 650.
 — *acclivus*, 663.
 — *æqualis*, 674. (Pl. LXXI, figs. 4a-5.)
 — *æquitermus*, 658, 659. (Pl. LXXI, fig. 12.)
 — *æternalis*, 650, 683.
 — *Agassizi*, 656, 669. (Pl. LXIX, fig. 4.)
 — *alabamensis*, 650, 678, 680.
 — *allophylus*, 685. (Pl. LXXI, fig. 17.)
 — *amabilis*, 650.
 — *americanus*, 686. (Pl. LXXV, figs. 10-13c.)
 — *annosus*, 650.
 — *altidorsatus*, 650.
 — *asper* (*Goldf.*), 690.
 — *asper* (M. and W.), 690. (Pl. LXVIII, figs. 9a, b.)
 — *batiola*, 650, 674.

- Platycrinus Blairi*, 650.
 — *bedfordensis*, 650.
 — *bloomfieldensis*, 650, 668.
 — *bonoensis*, 682, 683. (Pl. LXIX, fig. 6.)
 — *boonvillensis*, 681. (Pl. LXXII, figs. 8a-9.)
 — *brevinodus*, 688, 690. (Pl. LXX, figs. 2, 5, 6a, b.)
 — *Britsi*, 659. (Pl. LXXI, fig. 10.)
 — *Broadheadi*, 650, 686.
 — *burlingtonensis*, 103, 649, 653, 657, 661, 681. (Pl. LXIX, figs. 3a-i.)
 — *caducus*, 650, 683.
 — *calyculus*, 650.
 — *canaliculatus*, 689. (Pl. LXXV, figs. 7a, b.)
 — *carchesium*, 650, 656.
 — *cavus*, 715. (Pl. LXVII, figs. 8a, b.)
 — *clytis*, 651, 695.
 — *chouteauensis*, 650.
 — *Colletti*, 650.
 — *concinus*, 650.
 — *contritus*, 667. (Pl. LXXI, fig. 8.)
 — *corrugatus*, 651, 713.
 — *corbuliformis*, 657. (Pl. LXXI, figs. 11a, b.)
 — *curryvillensis*, 651, 658.
 — *Davisi*, 684. (Pl. LXX, fig. 14.)
 — *discoideus* (O. and Sh.), 103, 713, 716. (Pl. III, fig. 17; LXVI, figs. 10a-c.)
 — *discoideus* (Hall, 1858), 713, 724.
 — *eboraceus*, 650.
 — *elegans*, 669.
 — *eminulus*, 712. (Pl. LXVIII, figs. 13a-c.)
 — *eriensis*, 647, 676.
 — *excavatus*, 649, 718. (Pl. LXVI, fig. 4.)
 — *exsertus*, 651, 653, 655.
 — *geometricus*, 697. (Pl. LXVII, fig. 10; LXVIII, fig. 8.)
 — *Georgei*, 651, 677.
 — *glyptus*, 693, 720. (Pl. LXVII, figs. 4-6.)
 — *Gorbyi*, 716. (Pl. LXVIII, fig. 15.)
 — *graphicus*, 672. (Pl. LXXI, fig. 7.)
 — *Halli*, 103, 662, 664. (Pl. LXXII, figs. 6a-7b.)
 — *Haydeni*, 650.
 — *hemisphericus*, 703, 709, 793. (Pl. LXVI, figs. 1a-d.)
 — *Platycrinus Huntsvillæ*, 84, 678. (Pl. LXXXIII, figs. 6-12.)
 — *incomptus*, 648, 664. (Pl. LXXI, figs. 1, 2, 3.)
 — *insolens*, 659. (Pl. LXXI, fig. 15.)
 — *inornatus*, 651, 653.
 — *lævis*, 649.
 — *lautus*, 651, 653, 655.
 — *Leai*, 746.
 — *lodensis*, 666. (Pl. LXXI, fig. 6.)
 — *marginatus*, 650.
 — *monroensis*, 651, 678.
 — *multibrachiatus*, 651, 713.
 — *niotensis*, 682. (Pl. LXXI, fig. 9.)
 — *nodobrachiatus* (Hall, 1861), 651, 708.
 — *nodobrachiatus* (Hall, 1858), 651, 653, 655.
 — *nodostriatus*, 688, 698. (Pl. LXVI, figs. 5a, b; LXX, figs. 3-4c.)
 — *nodosus*, 650.
 — *nodulosus*, 651, 701.
 — *nucleiformis*, 651, 653, 655.
 — *occidentalis*, 728.
 — *olla* (Hall, not de Kon.), 651.
 — *ollicula*, 667.
 — *ornigranulus*, 701. (Pl. LXVI, fig. 8; LXVIII, figs. 10a-12b; LXXII, fig. 10.)
 — *Oweni*, 651, 710.
 — *parvinodus*, 696, 701. (Pl. LXVIII, figs. 6a, b.)
 — *parvulus*, 773.
 — *parvus*, 651, 735, 737.
 — *peculiaris*, 700. (Pl. LXVIII, figs. 7a, b; LXXI, fig. 16.)
 — *penicillus*, 651, 678.
 — *pentagonus*, 650.
 — *perasper*, 708.
 — *planobasalis*, 651, 661.
 — *pileiformis*, 656, 663. (Pl. LXIX, fig. 5; LXX, figs. 13a-b.)
 — *pisum*, 660. (Pl. LXXI, figs. 13a-b.)
 — *planus* (Hall), 651, 662, 668.
 — *planus* (O. and Sh.), 668, 670. (Pl. LXIX, figs. 2a-d.)
 — *plenus*, 651, 678.
 — *pleuroviminus*, 651, 724.
 — *plumosus*, 651, 735.
 — *pocilliformis*, 706. (Pl. LXVIII, figs. 2a, b.)
 — *præmaturus*, 651, 734.
 — *prænuntius*, 651, 720.
 — *prattenanus*, 651, 678.

- Platycrinus Pratteni**, 668, **671**. (Pl. LXX, figs. 11, 12.)
 — *pulchellus*, 651, 713.
 — *pumilus*, 650.
 — *punctobrachiatus*, 750.
 — **quinquenodus**, **661**. (Pl. LXXI, figs. 14a-c.)
 — *ramulosus*, 651, 735, 737.
 — **regalis**, **710**, 712. (Pl. LXXII, figs. 1, 2.)
 — *retarius*, 735.
 — *richfieldensis*, 651, 672.
 — *rotundus*, 651, 691.
 — **Saffordi**, **694**. (Pl. LXVII, figs. 1-3.)
 — **Sampsoni**, **673**. (Pl. LXX, fig. 10.)
 — Særæ, 84, **677**, 682. (Pl. LXIX, fig. 7; LXX, fig. 1.)
 — **scobina**, **695**, 697. (Pl. LXVIII, figs. 14a, b.)
 — **sculptus**, **691**, 693, 695. (Pl. LXVIII, fig. 5; LXXV, figs. 8, 9.)
 — *shumardianus*, 651, 713.
 — **spinifer**, **708**. (Pl. LXVI, fig. 7.)
 — — var. *elongatus*, **709**. (Pl. LXVII, fig. 7.)
 — *striobrachiatus*, 651, 713.
 — *subspinosus*, 717. (Pl. LXVI, figs. 9a, b.)
 — *subspinulosus*, **684**, 685, 754. (Pl. LXVI, figs. 2a, b; LXX, fig. 9.)
 — *sulcatus*, 651, 718.
 — *symmetricus*, 103, 118, **655**. (Pl. III, fig. 16; LXIX, figs. 1a-c.)
 — *tennesseensis*, 651, 731.
 — *tentaculatus*, 651, 733.
 — *tenuibrachiatus*, **687**, 699. (Pl. LXX, figs. 7, 8.)
 — **truncatulus**, **647**, **675**. (Pl. LXVII, figs. 11a, b; LXXI, figs. 18a, b.)
 — *truncatus*, 651, 686.
 — *tuberosus*, 651, 720, 728.
 — **verrucosus**, **705**, 706, 709. (Pl. LXVI, figs. 3a, b; LXVIII, figs. 1a-d.)
 — *vezabilis*, 650.
 — **Wortheni**, **702**. (Pl. LXVII, fig. 9.)
 — **Yandelli**, 103, **706**, 708. (Pl. LXVI, figs. 6a-c; LXVIII, figs. 3a-c.)
 — — var. *perasper*, **708**. (Pl. LXVIII, figs. 4a, b.)
 — undescribed species from England, 644.
Pleurocrinus, 647, 649.
Plicatocrinidæ, 30.
Polycrinides, 18.
Polymera, 31.
Polypeltes, 365.
 Pores in Poteriocrinidæ, 114, 116. (Pl. VII, figs. 4, 7, 8, 9.)
Porocrinus, 67, 146.
 Position for figuring, 37.
 Postpalmaris, 34, 73, 76.
Poteriocrinidæ, 58, 87, 116, 155, 161.
Poteriocrinus, 13, 87, 127, 159.
 — *missouriensis*, 78.
Pradocrinus, 519, 521.
 — *amplus*, 530.
 Primary brachials, 34.
 Primary plates, 38.
 Proximal, 37.
Proximal plates (proximals), 90, 95.
 Proximal ring of base, 54.
Pseudomonocyclicla, 59.
Pterotocrinus, 77, 79, 83, 112, 741, 781, 791. (Pl. LXXIX, fig. 10.)
 — **acutus**, **799**. (Pl. LXXIX, figs. 3a-g.)
 — — var. *bifurcatus*, **801**. (Pl. LXXIX, figs. 9a, b.)
 — **capitalis**, 793, **794**, 799. (Pl. LXXIX, figs. 6a, b.)
 — **chesterensis**, **802**. (Pl. LXXIX, figs. 5a, b.)
 — *cornigerus*, 783.
 — **coronarius**, **795**. (Pl. LXXIX, figs. 7a, b.)
 — **crassus**, **801**. (Pl. LXXIX, fig. 8.)
 — **depressus**, **796**. (Pl. LXXIX, figs. 2a-c.)
 — **pyramidalis**, **798**. (Pl. LXXIX, figs. 4a, b.)
 — *rugosus*, 799, 801.
 — *sexlobatus*, 784.
 — *spatulatus*, 799.
Ptychocrinus, 188, **197**.
 — *angularis*, 199.
 — **parvus**, 177, 199. (Pl. XVIII, figs. 1a, b, 2.)
 — *priscus*, 198.
 — *splendens*, 198. (Pl. XVIII, figs. 3a, b.)
Pycnocrinidæ, 17.
Pycnocrinus, 175, 268, 273.
 — *Shafferi*, 272.
Pyxidocrinus, 519, 521.
 Quinquelocular or Dorsal organ, 45.
 Radials (Radialia), 15, 33, **68**.
 — compound, 71, 158.
 — limits of, 67.

- Radial dome plates, 36, **103**, 104.
 Radial facets, 87, 161.
 Radial, 35, 72, 126.
 Recuperative power, 135.
 Regalis group, **710**.
 Respiratory pores, 35, 122, 238, 311.
Reteocrinidæ, 106, 113, 147, **173**, 803.
Reteocrinus, 67, 113, 119, 175, **176**.
 — *Bæri*, 177, 185.
 — *cognatus*, 180.
 — *fimbriatus*, 177, **179**. (Pl. IX, fig. 4.)
 — *gracilis*, 177, 199.
 — *magnificus*, 181. (Pl. IX, fig. 2.)
 — *Onealli*, **179**. (Pl. IX, figs. 1a-f.)
 — *Pattersoni*, 177.
 — *Richardsoni*, 177, 271.
 — *stellaris*, 77, 177, **178**. (Pl. IX, figs. 3a-c.)
Rhaphanocrinus, 215, 258.
 — *sculptus*, **260**. (Pl. XI, fig. 3.)
 — *subnodosus*, **259**. (Pl. XI, fig. 2.)
 — *Wachsmuthi*, 259.
Rhizocrinus, 28, 40, 46, 58, 62, 94, 142.
 — *lofotensis*, 63, 70.
 — *Rawsoni*, 51, 63, 70. (Pl. VI, figs. 7a, b.)
Rhodocrinidæ, 106, 124, 165, 170, **215**, 238.
Rhodocrinus, 13, 41, 44, 69, 83, 215, **218**, 233, 238, 249, 261.
 — *asperatus*, 254.
 — *Barrisi*, **230**. (Pl. XII, figs. 3, 4a-d, 5a, b.)
 — — var. *divergens*, 230.
 — — var. *striatus*, **231**. (Pl. XII, fig. 6.)
 — *Benedicti*, **224**.
 — *coxanus*, **222**. (Pl. XIII, figs. 6, 7.)
 — *cælatus*, 228.
 — *gonatodes*, 80, 219.
 — *gracilis*, 220.
 — *Halli*, 196, 219.
 — *Kirbyi*, 44, **226**, 228, 337. (Pl. XII, figs. 1a-d.)
 — *melissa*, 219, 263.
 — *microbasilis*, 192, 219, 256.
 — *nanus*, 44, **228**. (Pl. XI, figs. 7a, b; XII, figs. 2a, b.)
 — *nodulosus*, **225**. (Pl. XIII, fig. 8.)
 — *parvus*, **229**.
 — *polydactylus*, 222.
 — *pyriformis*, 192, 219, 255.
 — *quingulobus*, 192.
Rhodocrinus rectus, 220.
 — *sculptus*, 228.
 — *spinosus*, 220.
 — *stellaris*, 219, 236.
 — *truncatus*, **231**. (Pl. XIII, figs. 2a-f.)
 — *tuberculatus*, **232**. (Pl. XIII, figs. 3, 4.)
 — *varsoviensis*, 220.
 — *verus*, 219.
 — *vesperalis*, 219, 251.
 — *Wachsmuthi*, **222**. (Pl. XIII, figs. 5a-d; XV, fig. 7.)
 — *watersianus*, **221**, 229. (Pl. XII, fig. 9.)
 — *Whitei*, **223**. (Pl. III, fig. 24; XIII, figs. 1a-c; XV, figs. 6a, b.)
 — — var. *burlingtonensis*, 223.
 — *Wortheni*, **220**. (Pl. XI, fig. 6; XII, figs. 7a-c.)
 — — var. *urceolatus*, **221**. (Pl. XII, figs. 8a, b.)
Ripidocrinus, 76, 86, 215, 262.
 Right and left, 37.
 Root, 32, 39.
 Rosette, 54, 141.
Saccocrinus, 519, 522.
 — *Benedicti*, 527.
 — *Christyi*, 522, 525.
 — *Egani*, 525.
 — *Gorbyi*, 521.
 — *Howardi*, 529.
 — *infelix*, 525.
 — *marcouanus*, 523.
 — *necis*, 524.
 — *ornatus*, 527.
 — *pyriformis*, 526.
 — *semiradiatus*, 289.
 — *speciosus*, 521, 528.
 — *tennesseensis*, 528.
 — *urniformis*, 526.
 — *Whitfieldi*, 522.
 — *Whitei*, 530.
Sagenocrinus expansus, 219.
 Saræ group, **677**.
 Saumplättchen, see covering plates, 36.
Scaphiocrinus, 44, 159.
 — *elegans*, 138. (Pl. VII, figs. 1a, b.)
 — *unicus*, 138. (Pl. VII, fig. 6.)
 — *Swallovi*, 138. (Pl. VII, fig. 8.)
Scapulae, 13.
Schizocrinus, 77.
 Sculptus group, 691.
Seyphocrinus, 264.

- Scytalocrinus**, 160.
 — **validus**, 138. (Pl. VII, 2a, b, 3.)
 — **nov. sp.** (Pl. VII, fig. 7.)
 — **robustus**, 566.
 Secondary brachials, 34.
 Side pieces; see Adambulacral plates, 100.
Siphonocrinus, 120, 122, 188, 209.
 — **armosus**, 107, 122, 211. (Pl. XIX, figs. 3a-c.)
 — **nobilis**, 212. (Pl. XIX, figs. 1a, b, 2a-c.)
 — **pentagonus**, 213. (Pl. XIX, figs. 4a, b.)
 Species, recognition of, 155.
 — characters of, 156.
 — descriptions of, 652.
 Spines, movable, 748, 750.
Sphaerocrinus concavus, 482.
Sphaeronites, 15.
Sphaeroidocrinacea, 29.
Sphaeroidocrinidae = *syn. of Camerata*, 25.
Spyridiocrinus, 365.
Steganocrinus, 76, 85, 101, 110, 293, 550, 554, 578, 639, 720.
 — **araneolus**, 160, 581, 723. (Pl. LXI, figs. 2a, b.)
 — *Benedicti*, 567.
 — **concinus**, 582. (Pl. LXI, figs. 5a, b.)
 — **globosus**, 585. (Pl. LXI, fig. 6.)
 — **pentagonus**, 110, 142, 579, 723. (Pl. LXI, figs. 3a-4b.)
 — **sculptus**, 78, 86, 160, 293, 583. (Pl. LXI, figs. 1a-f.)
Stelidiocrinus, 79, 264, 279.
 — **argutus**, 280. (Pl. XXIV, fig. 6.)
 — **capitulum**, 280.
 — **laevis**, 280.
 — **ovalis**, 280.
 Stem, 32, 38, 155.
 — figures of; Pl. I and II; VI, figs. 11, 12.
 — growth of, 39.
 — divided longitudinally, 41.
 — respiratory function of, 47.
 — semi-free, 49, 51.
 — with coalesced infrabasals. (Pl. VI, fig. 11.)
 — of **Barycrinus**, 45.
 — of **Cupressocrinus**, 45.
 — of **Megistocrinus**, 46.
 — of **Platycrinus**, 42.
 — of **Rhizocrinus**, 63.
 — of **Strotocrinus**, 639.
 Stem joints, 32, 41.
 — — top joint (centrodorsal), 33, 59, 61, 64.
 — — top joint (youngest joint), 59, 63, 65.
Stemmatocrinus, 59, 80, 127, 133, 160, 162.
Stephanocrinus, 146.
 — **angulatus**. (Pl. VII, figs. 12, 13.)
Stereocrinus, 77, 124, 265, 324.
 — **Barrisi**, 326. (Pl. XXV, figs. 9a, b.)
 — **triangulatus**, 325, 326. (Pl. XXV, figs. 8a, b.)
 — — var. *liratus*, 326.
Stomatocrinoidea, 25, 148.
Storthingocrinus, 57, 647.
 — *asper*, 690.
Strotocrinus, 76, 85, 110, 551, 554, 626, 637, 638.
 — *asper*, 596.
 — *asperrimus*, 575.
 — *ægilops*, 628.
 — *bloomfieldensis*, 638.
 — *clivus*, 630.
 — *dilatatus*, 595.
 — *ectypus*, 611.
 — *erodus*, 630.
 — **glyptus**, 640. (Pl. LX, figs. 1a-c; LXV, figs. 2a, b.)
 — *insculptus*, 630.
 — *liratus*, 633.
 — *perumbrosus*, 638, 640.
 — **regalis**, 39, 638, 640. (Pl. IV, fig. 4; LXV, figs. 1a-d.)
 — *rudis*, 630.
 — *subumbrosus*, 633.
 — *tenuiradiatus*, 634.
 — *umbrosus*, 628.
Stylida, 17.
Sub-basals, 66.
Subradials (sous-radiales), 17, 30.
 Subspinulosus group, 683.
 Subtegminial, 35.
 Subtentacular canal, 36, 100.
 Superimposed plates, 119, 121.
 Super-radials, 33.
 Supplementary plates, 34, 38, 105, 154.
 Suture, 37.
 Symmetry, bilateral, 134, 148.
 — irregular, 146.
 — pentamerous, 134, 146, 148, 165.
Symbathocrinus, 57, 87, 91, 136, 157, 172.
 — **Wachsmuthi**. (Pl. III, fig. 25; VIII, figs. 8, 9.)

- Symbathocrinus Swallovi.** (Pl. VIII, fig. 7.)
 Syzygy, 34, 81.
Talarocrinus, 79, 741, **781**, 782, 793.
 — sp. (?) (Pl. LXXVIII, figs. 9a, b.)
 — **cornigerus**, **783**, 785. (Pl. LXXVIII, figs. 6a-7b.)
 — **decornis**, **788**. (Pl. III, fig. 19; LXXVIII, figs. 3a-c.)
 — **elegans**, 786.
 — **ovatus**, **787**. (Pl. LXXVIII, figs. 2a, b.)
 — **sexlobatus**, **784**. (Pl. LXXVIII, figs. 1a-c.)
 — **simplex**, **790**. (Pl. LXXVIII, figs. 8a, b.)
 — **subglobosus**, **789**. (Pl. LXXIX, figs. 1a, b.)
 — **symmetricus**, **786**. (Pl. LXXVIII, figs. 4a-5.)
Tanaocrinus, 67, 173, **185**.
 — **typus**, **186**. (Pl. IX, figs. 7a-c.)
Taxocrinus, 17, 28, 43, 70, 93, 118, 138, 149. (Pl. VI, fig. 16.)
 — **intermedius**, 118. (Pl. III, fig. 11; VIII, figs. 5a, b.)
 — **Thiemei**, 139.
Technocrinus, 264, **304**.
 — **Andrewsi**, 306. (Pl. XXIV, fig. 3.)
 — **sculptus**, 305.
 — **spinulosus**, **305**. (Pl. XXII, fig. 3.)
 — **striatus**, 305.
Tegmen, 33.
 — inner floor of, 106. (Pl. V, figs. 13-17.)
 — of **Actinocrinus** and **Batoocrinus**, 109, 121.
 — of **Glyptocrinus**, 24, 113, 120.
 — of **Platycrinus**, 24, 111.
Tegminal, 35.
Teleiocrinus, 85, 102, 121, 143, 550, 554, 576, **626**, 637. (Pl. IV, fig. 1.)
 — **adolescens**, **635**, 636. (Pl. LIX, fig. 4.)
 — **ægilops**, 628.
 — **althea**, **632**. (Pl. LX, fig. 4; LXIII, fig. 9.)
 — **clivus**, 630.
 — **erodus**, 630.
 — **insculptus**, 630.
 — **liratus**, **633**. (Pl. LX, fig. 3.)
 — **rudis**, **630**. (Pl. LIX, figs. 1-3.)
 — **tenuiradiatus**, **634**. (Pl. LIX, figs. 5, 6.)
 — **umbrosus**, 56, **628**, 631. (Pl. LIX, fig. 7; LX, figs. 2a-d.)
 Terminal plates of stem, 48, 51.
 Terminology, 32, 76.
Tessellata, 15, 23.
Tetramera, 31.
Thaumatoocrinus, 72, 117, 139.
 — **renovatus**. (Pl. III, fig. 9.)
Thylacocrinus, 215, **248**.
 — **Clarkei**, **248**. (Pl. XIII, figs. 11a, b.)
 — **Vannioti**, 248.
Thysanocrinidae, 72, 124, 165, 170, **188**, 217.
Thysanocrinus, 188, **190**.
 — **aculeatus**, 192.
 — **brachiatus**, **195**. (Pl. XVIII, fig. 7.)
 — **canaliculatus**, 192.
 — **Halli**, **196**. (Pl. XIII, figs. 9a, b.)
 — **immaturus**, 192, 206.
 — **inornatus**, 191, **193**. (Pl. XVIII, figs. 6a-d; XIX, fig. 5.)
 — **liliiformis**, 191, **192**. (Pl. XVIII, fig. 4.)
 — **occidentalis**, **194**. (Pl. XVIII, figs. 5a-c.)
 — — var. *increbescens*, 195.
 — **microbasilis**, 192, 256.
 — **pyriformis**, 192, 255.
Tiarocrinus, 146.
 Transition forms, 146.
Trematoocrinus, 234.
 — **fiscellus**, 245.
 — **papillatus**, 242.
 — **reticulatus**, 244.
 — **robustus**, 239.
 — **spinigerus**, 247.
 — **tuberculosus**, 243.
 — **typus**, 242.
Triacrinus, 57.
Tribrachioocrinus, 148, 158.
Trimera, 31.
Trochocrinites, 519, 521.
 — **lavis**, 521.
 Trochites, 11.
 Truncatulus group, **675**.
Trybliocrinus, 216.
Turbinocrinites, 292, 294.
Uintaocrinus, 63, 145.
Uloocrinus, 133.
 Uniserial, 34, 78.
Uperocrinus, 366, 434.
 — **pistilliformis**, 437.
 — **pyriformis**, 434, 437.
 Upper face, 37.
 "Up" and "down," 37.

- | | |
|---|---|
| <p><i>Vault</i>, 29, 105, 121, 148.
 — is a modified disk, 124, 149.
 Ventral disk, 33, 35, 95, 118, 121, 150, 154.
 (Pl. III, figs. 1-25; IV, figs. 1-5.)
 Ventral sac (tube), 35, 114, 123, 157, 161.
 (Pl. VII, figs. 1-12.)</p> | <p>Water pores, 123.
 Xenocrinus, 67, 173, 175, 182.
 — Baeri, 183. (Pl. IX, figs. 5a-d.)
 — penicillus, 183. (Pl. IX, figs. 6a, b.)
 Zeacrinus, 52.
 Zophocrinus, 146.</p> |
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